

DRAFT Background / Reference Memorandum

Delta Region

**Integrated Flood
Management**

**Key Considerations and
Statewide Implications**

California Department of Water Resources

Overview

This Background / Reference Memorandum (BRM) presents highlights from flood-related technical, legislative and funding information regarding the Sacramento-San Joaquin Delta (Delta), with emphasis on activities by the California Department of Water Resources (DWR). The BRM is intended to provide historical and existing conditions (year 2011) context for DWR's use in conveying strategies for future investments in integrated flood management in the Delta under a separate document¹.

The State of California has entrusted DWR as the agency with the responsibility for managing water flow through the Delta and for representing State interests in Delta levees. DWR invests in the Delta levee system to protect clear and identifiable State interests:

- Human life, public health, and property within the Delta;
- Water quality and water supply for agriculture, ecosystem, and municipal and industrial water users within the Delta and water users outside of the Delta;
- Ecosystem protection and enhancement, including protection and recovery of threatened and endangered species;
- Critical infrastructure such as highways, railroads, aqueducts, and pumping plants;
- Other infrastructure such as transmission lines (electric & petroleum), shipping channels, and public infrastructure (water and wastewater treatment plants);
- Agriculture and recreation; and
- Cultural, historical, aesthetic, and other values included in “Delta as a place.”

State legislation and modifications to the California Water and Resources codes have repeatedly demonstrated the State’s interest in preserving the Delta and the importance of Delta levees. The legislation and modifications to the codes have made strong statements about the importance of the Delta, provided direction for the Department’s levee programs, and provided funding for flood management activities and environmental stewardship in the Delta.

¹ FloodSAFE – A Framework for Department of Water Resources Investments in Delta Integrated Flood Management dated February 14, 2011 draft.

This BRM should be considered a reference document. Due to the large number of existing documents on the Delta and its levees, this BRM provides highlights of important material with references to other documents for more detailed information. This base information should be useful when considering modifications to investment strategies for integrated flood management in the Delta.

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Abbreviations and Acronyms

AB	Assembly Bill
AAS	Anthropogenic Accommodation Space
BDCP	Bay Delta Conservation Plan
BRM	Background / Reference Memorandum
Cal EMA	California Emergency Management Agency
CBSC	California Building Standards Commission
CEQA	California Environmental Quality Act
CONOPS	catastrophic concept of operations
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DFG	Department of Fish and Game
DFM	Division of Flood Management
DHCCP	Delta Habitat Conservation and Conveyance Program
Delta LTMS	Delta Long-Term Management Strategy
DPC	Delta Protection Commission
DRMS	Delta Risk Management Strategy
DSC	Delta Stewardship Council
DWR	Department of Water Resources
EIP	Early Implementation Project
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FESSRO	FloodSAFE Environmental Stewardship and Statewide Resources Office
FloodSAFE	California's FloodSAFE initiative for integrated flood management
FY	Fiscal Year

GCM	Global Climate Model
HMP	Hazard Mitigation Plan
LiDAR	Light Detection and Ranging
LMA	local maintaining agency
NIMS NFIP	National Flood Insurance Program
NSN	Northern Sierra Nevada
NGVD	National Geodetic Vertical Datum (Mean Sea Level)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OPC	Ocean Protection Council
PL 84-99	USACE Delta Specific guidelines for levee configuration
PPIC	Public Policy Institute of California
PRC	Public Resources Code
RD	reclamation district
SB	Senate Bill
SEMS	Standardized Emergency Management System
SPFC	State Plan of Flood Control
SSN	Southern Sierra Nevada
USACE	U.S. Army Corps of Engineers
USBR	Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
WC	California Water Code
WRDA	Water Resources Development Act

1 Introduction

1.1 Purpose of Background / Reference Memorandum (BRM)

The purpose of this BRM is to provide a summary of flood-related technical, legislative, and funding information regarding historical and existing (2011) flood management in the Sacramento-San Joaquin Delta (Delta). It provides contextual information for establishing DWR's strategies and policies for future Delta integrated flood management investments.

1.2 Delta Region

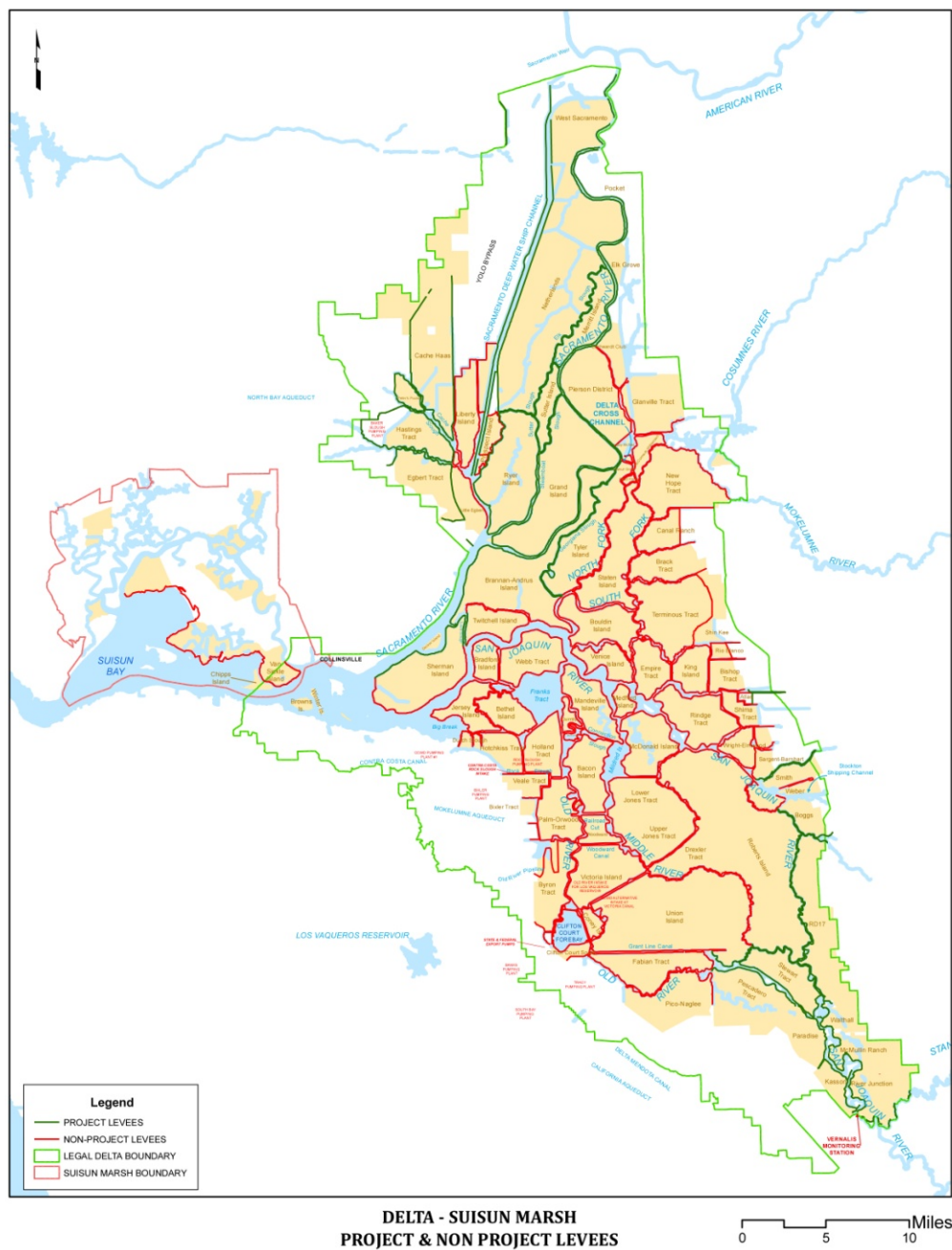
The Delta is formed at the confluence of the Sacramento and San Joaquin Rivers, which provides drainage for about 40 percent of California's total runoff. The Delta is important to California and the Nation in many ways, with levees defining hundreds of miles of protected, meandering waterways, in-channel islands and habitat. The recreational and habitat values of the Delta are irreplaceable. It is also the area where the flow transitions from fresh to salt water. The Delta consists of approximately 70 major islands and tracts encompassing about 700,000 acres of land. Without the levees, Delta land could not be used as it is today for highly productive farming habitat, homes, and conveyance of fresh water to support other areas of the state. People, property, agriculture, and infrastructure, including critical infrastructure (such as highways and railroads) depend upon levees to keep land areas that support these structures and functions from flooding. Virtually all assets and attributes of the Delta are dependent upon this levee system to protect them from flooding. Levees protect land areas near and below sea level and provide for a network of channels that direct movement of water for flood control, irrigation, and municipal and industrial uses across and through the Delta. Without the levees the Department would be unable to meet its salinity control obligations in the Delta (California Water Code (CWC) Section 12202) and protect the significant interest in the benefits provided by Delta levees, which have been codified in the Water Code (Section 12981 for example). The Suisun Marsh is another wetland area immediately downstream from the Delta, encompassing an additional 50,000 acres, and is often included in analyses of the Delta.

Delta levees are the last line of defense for protected islands against flood, and they are vulnerable to failure from many mechanisms. They can fail during high flood inflow to the Delta, from high tides and wind waves, from earthquakes, from undetected problems such as burrowing animals and foundation problems. In addition, the levee system is at risk from future changes such as sea level rise, climate change induced increases in flood inflows, continuing land subsidence, and other stressors.

The Delta's system of levees (about 385 miles of project levees² and 732 miles of non-project levees) and interconnected channels operate within a larger, multi-function, flood management system. The failure of one levee can increase the risk of other levee failures and increase the need for levee patrols, seepage control, and stability improvements, in addition to levee maintenance on adjoining islands in order to prevent additional levee failures. Flooding of one Delta island must be accompanied by flood fights on all adjacent islands to prevent progressive failures. In addition, the large benefits to regions outside the Delta make it imperative to consider system benefits in addition to on-island benefits when determining flood damage reduction in the Delta. Figure 1-1 shows the locations of project and non-project levees within the Delta (as defined in Section 12220 of the California Water Code) and Suisun Marsh.

² A project levee is a levee that is included as a facility of the State Plan of Flood Control.

Figure 1-1 Delta and Suisun Marsh



2 Background

This section provides brief background material on the Delta as context for integrated flood management. Readers wanting more detail are referred to documents on the Delta Vision web site (<http://deltavision.ca.gov/index.shtml>), the CALFED website (<http://calwater.ca.gov/>), Flood and Safety Topics on the DWR web site (<http://www.water.ca.gov/nav/nav.cfm?loc=t&id=100>) and references listed in Section 10 of this BRM. In addition, *Status and Trends of the Delta-Suisun Services* (URS, 2007) provides highlight information on the Delta.

2.1 Delta Reclamation

The rich and varied history of the Delta is discussed in depth in a recent white paper issued by the Delta Stewardship Council (DSC, 2010). More elaborate and detailed histories are provided by Thompson (1957, 1996, and 2006), Kelley (1989), and Mitchell (1994).

2.1.1 Pre-1850s Delta

Prior to the 1850s, the Delta was a vast expanse of marsh/wetlands that was subject to seasonal flooding by overflow of the rivers from winter rains and snowmelt. Large parts of the Delta were influenced by daily tides. The interaction of fluctuating sea levels, tidal marsh, and peat formation, combined with the influx of alluvial sediments from river floods in the region, formed a network of connecting channels bordered by natural levees surrounded by marsh plains. Delta peats and organic soils began to form about 11,000 years ago during the last gradual rise in sea level. This rise in sea level created tule marshes that covered a large percentage of the Central Valley. Peaty and other organic soils were formed due to repeated cycles where sediment brought by floods buried the tules and other vegetation in the marsh (DSC, 2010).

2.1.2 Delta Reclamation and Levee Construction

Reclamation of the Delta began in about 1850 in response to legislation³ to provide rich farm land to feed the large influx of gold miners in the upstream watersheds. Reclamation extended over many decades – most levees were constructed by the 1920s.

Many levees used to reclaim wetlands in the Delta during the mid-1800s were less than five feet in height and were first constructed using human and animal labor. Later, large steam-driven clamshell dredges were used to build and enlarge the levees to combat levee and land subsidence.

³ Arkansas Act of 1850.

Complicating these efforts were the effects of hydraulic mining. Beginning around 1853 and lasting approximately three decades, hydraulic mining in the Sierras washed vast amounts of silt, sand, and gravel into the streams and canyons of the Sierra foothills and into the Central Valley, resulting in reduced channel capacity downstream and increased flooding in the Sacramento Valley and the Delta. In 1893, the California Debris Commission was established. It had the combined tasks of regulating hydraulic mining, planning for improved navigation, deepening channels, protecting riverbanks, and affording relief from flood damages. The California Debris Commission began surveys of Sacramento Valley streams in July 1905 and developed a flood management plan in 1907. The plan included constructing and enlarging levees along rivers, creating bypasses to convey flows greater than the river's capacity, and dredging the Sacramento River to Suisun Bay.

2.2 Present Levee System

The present levee system includes about 1,100 miles of levees in the Delta and about 23 miles of levees in the Suisun Marsh.

See Figure 1-1 for locations of project and non-project levees.

2.2.1 Project Levees

Project levees are those levees that are part of federally authorized projects and are considered part of the State Plan of Flood Control (SPFC). The State Plan of Flood Control Descriptive Document (DWR, 2010) provides detailed information on project levees throughout the Central Valley including portions of the Central Valley located in the Delta.

The Central Valley Flood Protection Board (CVFPB), as the authorized representative of California and the non-federal sponsor for construction of project levees, has provided "assurances of cooperation" to the federal government. The assurances stipulate in part that the CVFPB or DWR will provide all lands, easements, and rights-of-way necessary to complete a project; pay for necessary highway, railroad, and bridge alterations; agree to not sue the United States for damages resulting from construction of facilities; and maintain and operate all facilities after they are completed. Depending on when a facility was authorized and constructed, there could be additional assurances of cooperation for levee replacement, rehabilitation, and repair. In turn, the State has turned most of the project levees over to local maintaining agencies (LMAs) for operation and maintenance.

Non-federal sponsors abiding by the federal flood control regulations are a condition for federal participation in the development of flood damage reduction projects. Federal flood control regulations are contained in 33 CFR Section 208. The regulations apply to all entities responsible for maintaining the completed facilities of the SPFC. The project levees in the Delta were built to COE design standards present at the time of construction.

2.2.2 Non-Project Levees

Most Delta levees, built and improved by local governmental entities and interests, referred to as Delta reclamation districts were built to drain islands and tracts, so they could be put into agricultural use. They were originally constructed before project levees and without assistance of the federal and State governments. These levees are not part of the State-federal flood protection system and are considered non-project levees. However, these non-project levees within the Delta have special status in the California Water Code – they are under the jurisdiction of public agencies (reclamation districts) and are eligible for State assistance due to their acknowledged special benefits to State interests (see Section 3).

When the first levees were built in the Delta, economy of construction was a priority, (W.C. 12300, 12900 *et seq.*) so they generally proceeded using readily available local materials and in some cases little design or construction supervision. As a result, some of the levees were built on peat soils and other unconsolidated foundations. The early levees themselves were usually of minimal cross section and not adequately compacted. Settling of the levees and seepage through and beneath the levees are more significant today since the levees have increased in height and are subjected to more hydraulic loading due to subsidence of the island land behind the levee.

Non-project levees in the Delta include only those shown on page 38 of DWR's Sacramento-San Joaquin Delta Atlas, dated 1993. It should be noted that there are other levees in California, including in the Delta, that are neither project levees nor non-project levees. They may be owned by public agencies or private entities, but they do not have the same eligibility status (relative to the Water Code and eligibility for State assistance) as the Delta non-project levees. Within this BRM, these levees are referred to as "unattributed."

2.3 Changes in the Delta

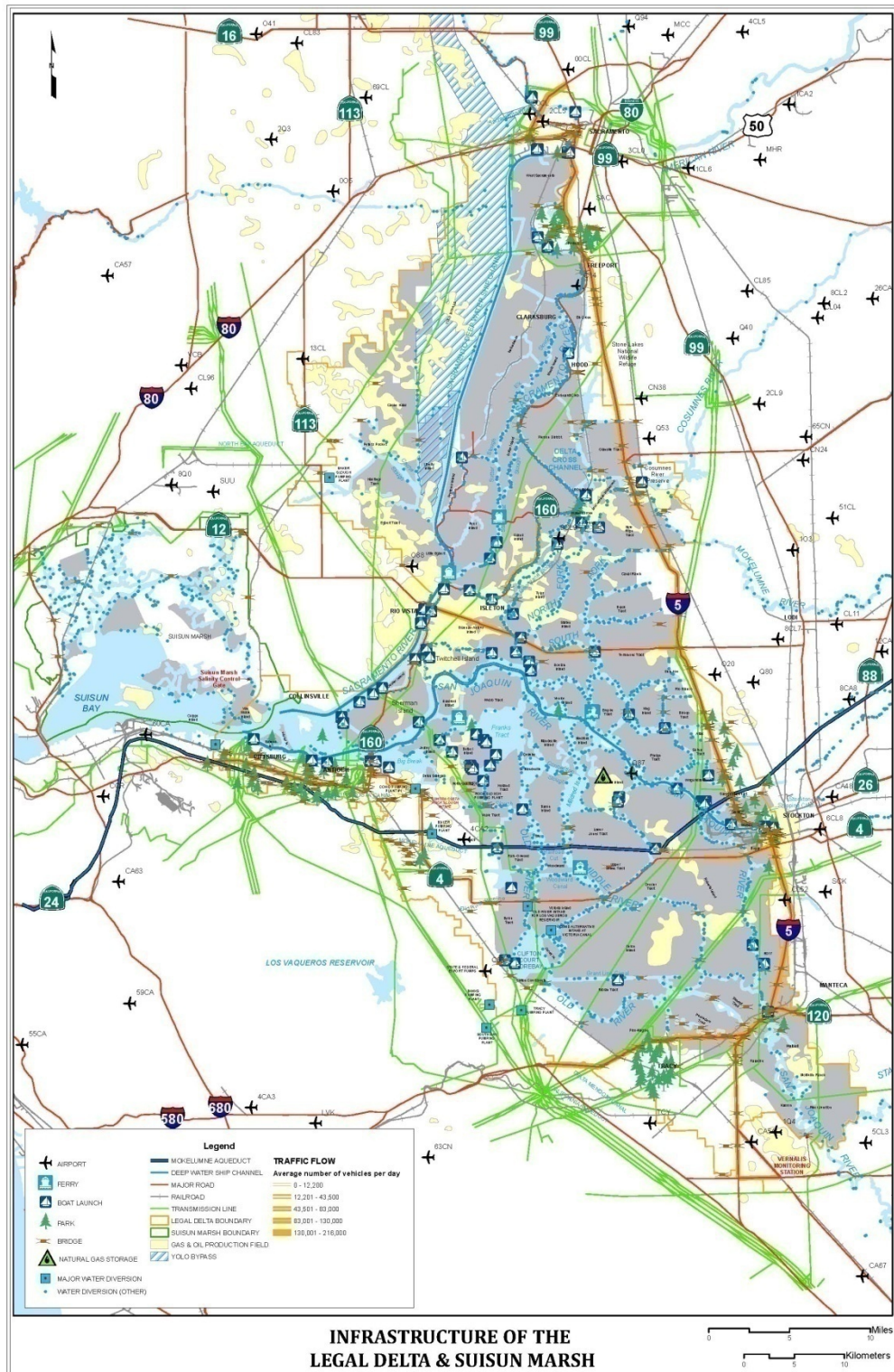
The Delta levees and the forces acting upon them are not static. Section 2.1 describes the transformation of the Delta from an intertidal marsh to land areas reclaimed primarily for agricultural use. Other changes within the Delta, especially subsidence, continue to influence its flood management.

2.3.1 Population/Land Use

While the character of the Delta continues to change, agriculture is still the primary land use. Conservation lands, managed lands, developed lands, and other land uses are contributing to its change. In addition, infrastructure is now widespread across much of the Delta and some of Suisun Marsh as shown in Figure 2-1.

The reclaimed land in the Delta was originally sparsely populated; however, the population of the Delta and Suisun Marsh grew to about 470,000 by 2000. Projections of the Department of Finance data suggest that population in the Delta area could approach 900,000 people by 2050 (DOF, 2004). Most of this population is within the Secondary Zone of the Delta. The population on Delta islands and tracts within the Primary Zone is expected to grow from about 26,000 in 2000 to about 67,000 in 2030.

Figure 2-1 Infrastructure within the Delta and Suisun Marsh



2.3.2 Land Subsidence

The rich organic peat soils in the Delta built up over thousands of years as plants grew and died in the wetland environment. The organic soils accumulated predominately due to sea level rise which kept the area saturated and continuously raised the water surface, allowing the organic material to increase. Since reclamation, some of this organic soil has blown away with the wind, some has burned, and much has decomposed (oxidized).

Subsidence in the Delta has several impacts, including impacts on water supply reliability and levee stability. Subsidence increases the volume of open space located below sea level, sometimes called Anthropogenic Accommodation Space (AAS). When a levee fails the AAS fills with water. In some cases the island is filled by salty water which may temporarily contaminate the freshwater pool in the Delta, making the water unsuitable for export until the freshwater pool is restored. The loss of export water may be a very significant problem for communities reliant on the Delta for municipal and industrial water supply or irrigation.

From the perspective of levee stability, there are some locations in the Delta where subsidence has run its course and will not further affect the levees; however, where subsidence is continuing, it will have a continuing effect on levee stability. As subsidence increases the depth of Delta islands, the levees will increase in size and be subjected to greater loads.

2.3.3 Changes within the Watershed

Changes in the Delta watershed have contributed to the evolution of the Delta. While major dams have attenuated normal wet season flood flows and spring snowmelt, the levee system along upstream rivers has had the opposite effect by preventing flows from reaching their natural floodplain and reducing this natural attenuation. Further building levees upstream and converting floodplain to farming has changed what was a lush floodplain habitat with significant biological diversity to a narrow strip that is no longer able to support the number and variety of species that historically inhabited the area. Also as a result of the loss of floodplain inundation the groundwater recharge that had occurred and resultant groundwater contributions to dry-season base flow were lost. Dams have prevented anadromous fish from reaching some of their spawning territory. Prevention of overbank flooding has reduced wetland habitat upstream. Agricultural and urban developments have further altered runoff patterns and have become sources of constituents that may further adversely affect aquatic species and ecosystem viability in the Delta.

2.3.4 Changes in Delta Ecosystem

A major thrust of DWR Delta programs for the past 15 to 20 years has been concern for the health of the Delta ecosystem.

The Delta watershed encompasses the Central Valley and western slopes of the Sierra Nevada Mountains. Development within the watershed has included construction of

dams, bypasses, and levees on the water courses which, ultimately, flow into the Delta. The dams retard minor to moderate flood flow, slowing flow toward the Delta. In contrast, the bypasses and levees along the water courses move the flow quickly and efficiently to the Delta.

Large flows that exceed the flood storage capacity of the dams move quickly into the channels with levees and bypasses. If the levees upstream of the Delta are able to contain the flood flows within the water courses, the flood flows which, historically, would have gone over bank and flooded portions of the valley, instead move into the Delta and threaten the Delta's levee system.

2.3.5 Changes over the Past 150 Years

- Canal and levee construction that separates rivers from their floodplains and eliminated channel meandering
- Upstream dam construction that caused alterations in hydrology and artificial flow regimes, coupled with numerous diversions
- Construction of highway and utility corridors for transit to Bay and coastal communities
- Development of dikes and draining of Delta-Suisun lands to convert marshes to other purposes, largely agricultural production (with hunting and recreation)
- Urbanization
- Salinity control barriers
- Wastewater treatment plants
- Construction of export water facilities for homes and jobs elsewhere in California
- Invasion by non-native species
- Reduction in seasonal and annual variability in salinity
- Introduction of toxic substances
- Food web problems for aquatic species

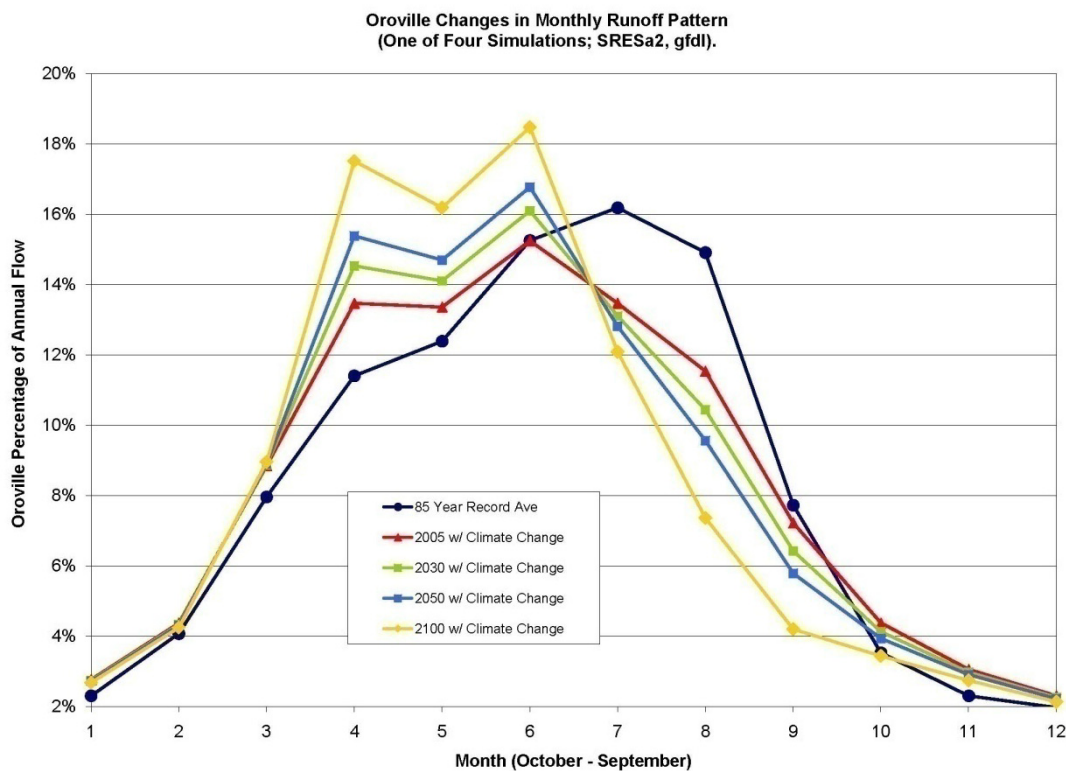
2.3.6 Future Change in Delta Inflow

Climate change will have an effect on the Delta. DWR staff has analyzed multiple models using a variety of methods to determine the effect on the water system, including the Delta. The fundamental result associated with climate change or global warming is

that characteristics which used to be regarded as constant (on average) can no longer be assumed to be constant. For Delta inflows, this has several implications:

- **Average Annual Inflows** – There are varying thoughts and no clear consensus on whether average annual flows into the Delta will increase, stay about the same, or decrease as a result of climate change. The Delta watershed appears to be in a large transition zone between more precipitation in the Northwest United States and less precipitation in the Southwest. Present climate models vary in their predictions.
- **Seasonal Distribution of Inflows** – While the yearly average inflow may remain relatively constant, there is a consensus that flows into the Delta will shift due to the warming. More precipitation in the Delta watershed will fall as rain and less as snow, causing a greater portion of the runoff to occur in the winter months rather than as late spring and early summer snowmelt. Figure 2-2 gives one illustration of the type of shift that may occur in unimpaired flows in Sierra streams. This illustration is based on the 150-year trend in monthly flows to Oroville Reservoir (1950 to 2100) for one general circulation model scenario.

Figure 2-2 Oroville Changes in Monthly Runoff Pattern



- **Frequency and Magnitude of Floods** – Just from a storm delivering more rain and less snow, the magnitude of a given flood will increase. Department climatologists and hydrologists have reviewed the climate models, including the effects associated with temperature change, and location to understand expected changes in runoff. In addition, their study shows storms are expected to be more intense. Accordingly, floods of a given frequency (e.g., the 1 percent annual flood) may become significantly larger. Quantitative information on how much larger is only beginning to become available. Two examples are:
 - The Delta Risk Management Strategy (DRMS) Flood Hazard studies provided data which, by combining flows and performing statistical analyses, indicated that the 1 percent annual flood that would occur in 2000 would increase to between 140 to 170 percent by year 2100.
 - A recent paper by Das et al. (2010) reports a more sophisticated analysis and confirms the direction and the significance of these expected changes.

“Analyses of future projections of flooding reveal that there is a general tendency toward the increase in the magnitude of three-day flood events. Specifically, by the end of the 21st century, all of the projections contain larger floods for both the moderate elevation Northern Sierra Nevada (NSN) watershed and for the high elevation Southern Sierra Nevada (SSN) watershed, even for [Global Climate Model] GCM simulations that project 8 to 15 percent decline of overall precipitation. The increases in flood magnitude are statistically significant (at $p = 0.01$ levels) for all the three GCMs for the period 2051 to 2099 By the end of the 21st century, the magnitudes of the largest floods increase to 110 to 150 percent of historical magnitudes.”

2.3.7 Sea Level Rise

While data shows variable results, within the Delta, sea levels are expected to increase and directly impact the Delta water levels. The Ocean Protection Council (OPC; 2011, March) has reviewed the available data and adopted a resolution on sea level rise that was informed by the advice of 16 State agencies along with renowned scientists, and provides guidance for State agencies regarding considerations of sea level rise. This guidance should be incorporated into the design of State projects and by non-state entities implementing projects funded by the State. It should be noted that the predicted sea level rise can be accommodated by gradually raising the levee crest over the coming decades. The OPC guidance includes principles to:

- Protect public health and safety and critical infrastructure;
- Protect, restore, and enhance ocean and coastal ecosystems on which our economy and well-being depend;

- Develop new communities which must be planned and designed for long-term sustainability in the face of climate change;
- Look for ways to facilitate adaptation of existing development and communities to reduce their vulnerability to climate change impact over time; and
- Begin now to adapt to the impacts of climate change.

Further, the OPC provides additional guidance for use in planning for sea level rise, as outlined in Table 2-1.

Table 2-1 Expected Sea Level Rise from OPC

Year	Estimate	Average of Models	Range of Models
2030		7 in	5-8 in.
2050		14 in	10-17 in.
2070	Low	23 in	17-27 in.
	Medium	24 in	18-29 in.
	High	27 in.	20-32 in.
2100	Low	40 in.	31-50 in.
	Medium	47 in.	37-60 in.
	High	55 in.	43-69 in.

2.4 Delta Levee Performance

Improvements in recent years to the Delta levee system have achieved higher levels of flood protection for assets of local and statewide importance on Delta islands. These improvements are a direct result of funding provided by the State being efficiently employed by local agencies to implement levee improvements. This has occurred during a time of increasing flood threat and is an example of a successful partnership of State and local agencies. The long-term record shows that Delta Islands and tracts suffer periodic levee failures, and will remain flood prone in the future. Delta flooding is usually the result of high stage from generalized flooding in the Delta drainage basin.

2.4.1 Historical Levee Failures

Table 2-2 provides an itemization of islands and tracts flooded since 1900. The data do not identify the date or time of the failure or state a cause (e.g., peak flow or high tide); however, Delta levee improvements performed since the late 1970s have gradually strengthened many miles of levees and made them less vulnerable to static loading.

The Sacramento and San Joaquin River Flood Control Projects, completed in the 1960s, have strengthened project levees upstream of the Delta, and upstream dams constructed in the 1950s and 1960s have lessened moderate flood flows. Delta levees are still vulnerable to failure, but analysis shows the number of static levee failures is going down.

Table 2-2 History of Delta and Suisun Flooding

Source: URS/JBA, 2008 and DSC, 201

Decade	No. of Islands Flooded
2001-2010	4
1991-2000	14
1981-1990	22
1971-1980	8
1961-1970	6
1951-1960	11
1941-1950	14
1931-1940	16
1921-1930	3
1911-1920	4

2.4.2 Estimates of Delta Island/Tract Flood Risk

Levee failures in the Delta have occurred in the past and will continue to occur, and the occurrences will be variable, based on many factors. Tides and water level surges will contribute to high water levels at some times, and these may or may not coincide with periods of high Delta inflow. Some Delta floods will have significant contributions from the Mokelumne, Cosumnes, San Joaquin, or other smaller tributaries, while others will be primarily from the Sacramento River. In addition, there will be isolated sunny-day levee failures like that on Upper Jones Tract in 2004. The recent DRMS analyzed present and future risks of levee failures by cause – seismic, inflow flood, or sunny-day/high-tide.

DRMS provided estimates of the annual chances of flooding for single and multiple Delta islands (URS/JBA, 2008; see the *DRMS Phase I Risk Analysis* for a complete discussion of causes and consequences associated with Delta levee failure).

2.5 Major Delta Levee Studies

Levee evaluations for individual Delta islands and tracts are used to periodically plan local levee repairs and upgrades. In addition, several Delta-wide levee studies have considered the vulnerability of Delta levees to potential failure. Each of these studies highlighted the relatively high chance of continued Delta levee failures. The

Reclamation Districts have individually been funded to produce 5-year plans for upgrading their levees.

2.5.1 *Bulletin 192-82*

The *Bulletin 192, Delta Levees Investigation* (DWR, 1982) examined the problems, feasibility, and costs of upgrading 537 miles of non-project levees protecting 56 islands and tracts in the Delta. The evaluations considered two concepts for Delta islands: (1) the Delta is a system of interdependent islands and tracts, and (2) each Delta island and tract is essentially independent of all other islands and tracts. The report lays out alternative levee improvement plans for each concept.

2.5.2 *CALFED Levee System Integrity Program Plan*

CALFED's Levee System Integrity Program Plan (CALFED, 2000), part of the CALFED Programmatic EIS/EIR, laid out a 30-year program intended to be cost-shared among beneficial users and the federal government to reconstruct Delta levees to the Corps of Engineers' PL 84-99 Delta Specific Standard. This action was intended to increase levee reliability and reduce emergency repair costs. The plan noted that levee districts meeting the PL 84-99 levee standard would be eligible for federal emergency assistance. In addition, DWR's ongoing Special Flood Control Projects effort would be continued to provide additional flood protection for key Delta levees that protect public benefits of statewide significance.

2.5.3 *Preliminary Seismic Risk Analysis*

The *Preliminary Seismic Risk Analysis Associated with Levee Failures in the Sacramento-San Joaquin Delta* (JBA, 2005) presents the results of a preliminary seismic risk analysis to estimate the effects of seismically initiated levee failures on Delta water quality and export and the economic consequences to the State. The purpose of the study was to provide an initial insight to the level of economic risk to the State and the risk-reduction opportunity (benefit) associated with undertaking a seismic upgrade of the Delta levees. The evaluation included the effects on the State economy resulting from breaches on Delta islands and tracts. As expected, Delta hydrodynamics and thus water quality can vary considerably depending on the details of the number and location of levee failures and number of islands flooded. However, the report concluded that breaches and island flooding in the south Delta are much more important than initially perceived. When southerly islands flood, the process of filling the islands draws saltwater into the Delta. Once saltwater is introduced into the southern Delta it is difficult to remove. The analysis showed that flooded south Delta islands trap the salt for a long period, blocking the fresh water from the export system. The degradation in water quality makes Delta water unsuitable for export, causing the pumps to remain unused for an extended period of time. The dependence of water quality and export flow on Delta levee integrity highlights the importance of the Delta levee system to the State economy.

2.5.4 Delta Risk Management Strategy (DRMS)

The Delta Risk Management Strategy (URS/JBA, 2008) evaluated levee failure risks in the Delta and Suisun Marsh. Phase 1 analyzes various risks to levees and the local and statewide consequences of levee failure considering subsidence, earthquakes, floods, changes due to climate change, and combinations of these factors. The analyses incorporated assumptions about flood protection, Delta levees, emergency response, land use, water operations, and others termed, “business as usual,” and a future environment projecting 50, 100, and 200 years ahead with a warming climate, ongoing subsidence, and sea level rise. Phase 2 identified measures to reduce the risks and consequences to the State resulting from Delta levee failure. DRMS evaluated seismic risks, high water risks, and dry-weather risks. DRMS concluded that while hydrologic flooding remains the most significant cause of levee failure, a seismic event presents the single greatest economic risk to the State resulting from levee failures in the Delta Region. If a moderate earthquake occurs close to the Delta, levees would fail, and as many as 32 islands could be flooded simultaneously. Depending upon many variables, this could result in statewide economic costs and impacts of \$25 billion or more. Under business-as-usual practices, coupled with climate change and sea level rise, high water conditions could cause about 140 levee failures in the Delta over the next 100 years. Multiple island failures caused by high water would likely be less severe to the State economics than failures from a major earthquake, but could still be extensive and could cause approximately \$8 billion or more in economic costs and impacts. All economic costs and impacts presented in this summary are expressed in 2005 dollars. It should be noted that changes in attention to the flood management system, including the Delta levees, represents a significant shift from the business as usual assumption inherent in the predictions in DRMS.

2.5.5 PPIC Report

The Public Policy Institute of California (PPIC) prepared an evaluation of Delta levees in their report, *Comparing Futures for the Sacramento-San Joaquin Delta* (PPIC, 2008). *The Technical Appendix B, Levee Decisions and Sustainability for the Delta*. The report presents an economic method for approaching the evaluation of Delta island levee upgrades and repairs. The economic analysis considered the feasibility of levee repair after failure based on costs of repair and the value of the assets (including infrastructure) flooded; however, it did not consider the network benefits of export water supply or the value of the Delta as a place. The evaluation used DRMS data for probability of levee failures and focused on 34 major Delta islands that make up most of the Delta’s Primary Zone. While this analysis suggests that from the perspective of on-island economics only, it is not cost effective to repair levees when they fail, there are major state benefits associated with the Delta levee system that must be considered before deciding to abandon any of these islands.

2.6 Delta Considerations

While some reports propose leaving islands flooded or claim that it is too expensive to continue a state grants program for levee maintenance, the fact remains that a large

portion of the state economy is dependent on export water, which in turn is dependent upon the Delta levees for preservation of water quality and for conveyance.

Considerations that make the Delta unique as a levee system and influence existing State programs:

- **Levees protect areas primarily below sea level.** The water surface that most Delta levees hold back on a daily basis is above the land area being protected.
- **Delta levees normally have water against them and act as dams** even though W.C. 6004.c states they shall not be considered to be dams. This is different than typical levees in upland areas that are designed to have water against them only infrequently. Deep floodplains in the Delta are dangerous to inhabitants and can create large logistical problems for flood recovery. In the Delta, failure of a levee would cause inundation that will continue indefinitely without action to close the breaches and pump the islands dry.
- **Delta water quality and export water quality is vulnerable to Delta levee failures.** Delta levee failures can degrade water quality because of salt water intrusion which may result from Delta levee failure, making it nearly useless for in-Delta needs and export. This loss of the fresh water hurts livelihoods and the State economy. For example, a levee failure in 1972 that occurred during a time when the system was most vulnerable shut down the export water system for about two weeks. To clear the salt from the Delta as a result of this levee failure required the release of more than half a million acre feet of water from storage. That cost in today's water market represents more than \$50 million in the value of the water alone.
- **It is costly to recover flooded islands.** Closing Delta levee breaches and dewatering inundated areas is expensive. The actual cost of recovery is dependent on conditions existing at the time and method of repair. It is a fact that the 2004 Jones Tract levee failure cost the State over \$20 million to repair the breach and to dewater the island. Considering all costs, including damage to the interior of the island from wave wash and property damage, the Jones Tract failure cost to State and local governments was estimated to be over \$40 million. The Jones Tract levee failure involved a single breach which affected flooding on two islands and threatened others, including Drexler, Roberts, McDonald and Woodward; however, multiple Delta levees can fail simultaneously during high water or during an earthquake, each of these failures would require some level of work resulting in multiplying expense and time for recovery. Based on the Jones Tract example, 20 island failures during an earthquake could cost over \$200 million just for levee repair and dewatering.
- **Delta levees preserve opportunities for major planning processes.** Ongoing major planning processes such as the Bay Delta Conservation Plan (BDCP), the Delta Stewardship Council's (DSC) Delta Plan, and others are relying on the levee system to preserve the best option for their program while proponents and

detractors discuss alternatives, considering ways to make the Delta more sustainable for water supply and the ecosystem. At this time, some advocate a higher level of flood protection for most Delta islands while others would not oppose allowing some islands to remain permanently flooded. In this time of diverse opinions and uncertainty, maintaining and improving most levees preserves opportunities that could be lost if some levees fail in the interim, especially if it proves economically infeasible to recover the islands.

- **Delta levees provide home for many wildlife and habitat species.** The Delta, in its current configuration, provides a healthy ecosystem for more than 500 species, including several rare and endangered species. The Delta levees preserve the in-channel islands that are the last remnant of the historic marsh that was typical of the Delta the Central Valley adjacent to the rivers of 150 years ago. Remaining habitat on the levees, on the in-channel islands and existing in areas of many of the Delta's agricultural islands support the Pacific flyway and several special status species. Further, preservation of existing habitats and islands for development of future habitats are critical to the success of BDCP and the interests of the DSC.
- **The Delta was built by a public/private partnership.** The Delta was reclaimed by reclamation districts (public agencies representing the interests of the owners of the Delta islands) by building and maintaining the current levee system. These reclamation districts continue to work on the levees to protect assets on the islands and extended benefits of the system. Now many of the assets that are protected are of significant State interest. Since the levees are part of the infrastructure that conveys water across the Delta to the export pumps, the Legislature provided for the State to share in the cost of maintenance and levee improvement. Since 1973, the State has contributed funds to pay more than 50 percent of the costs for qualifying maintenance and improvement of the Delta levee system, though it should be recognized that there are other costs associated with levees that do not qualify for reimbursement.
- **A flooded island may affect adjoining islands.** Historic meandering channels throughout the Delta and buried sand layers provide potential seepage pathways, wherein when one island floods the increased seepage pressures may affect levee stability on adjoining islands. Maintenance on islands adjoining a flooded island may also increase from more frequent and larger wind waves from longer wind fetch lengths.

There are a number of issues that must be considered when making decisions that affect the future of the Delta flood protection system, especially the Delta Levee system:

- If a decision were made today to address the single issue of export water reliability, it would require more than a decade before an alternative conveyance could be in place.

- During the time before alternative conveyance is built, the purity and availability of export flow would remain dependent on the Delta levee system.
- Delta levees provide the last line of flood protection for a wide variety of benefits.
- If levees fail and several islands flood, adverse consequences are expected far beyond the loss which occurs directly on the flooded islands and tracts.
- Most island surfaces are so far below sea level that the resulting deep water would contrast markedly with the 1850 “natural” Delta. The water body created by a levee failure may be good habitat for some species and poor habitat for others.
- Without Delta levees, tidal exchange from Suisun and San Francisco Bays would be increased and Delta salinity would be likely to rise at least during dry seasons and dry years. Water supply conveyance to remaining Delta islands, to Contra Costa County, and to the State Water Project and the Central Valley Project may be disrupted by salinity intrusion some of the time.
- Infrastructure systems, including Delta highways and pipelines, might be blocked.
- Delta towns and their economic activity might be jeopardized.

3 Importance of Delta Levees to the State

Virtually all assets and attributes of the Delta, including many benefits that accrue to the State at large, are dependent upon the Delta levee system. Levees protect land areas near and below sea level and provide for a network of channels that direct movement of water across the Delta. The State of California has significant interest in the benefits provided by the Delta and protected by the Delta levees. This interest is manifest in funding support for levee maintenance and improvement which has been codified in California's Water and Resources codes. The Water Code requires the DWR to develop and implement a program of flood control projects (section 12311a) that has as its primary purpose the protection of discrete and identifiable public benefits. This requirement has the effect of separating islands into categories for qualifying to receive funding under the Delta Special Flood Control Projects Program. DWR recognizes that not all levees provide public benefit or are of equal importance and that legislative guidance, fund source, funding availability, local participation, and priorities, will guide where State investments should be directed.

This section describes some of the important public benefit of the Delta levees to the State of California.

3.1 Protection Provided by Delta Levees

Delta levees provide a wide array of local and statewide benefits. Delta levees protect the habitat that supports the ecosystem, infrastructure that is critical to California's economy and support conveyance of water supplies for 25 million people and 3 million acres of farmland in regions south of the Delta.

Levees for Delta islands and tracts hold significant State interest due to protection provided to:

- Human life and public health
- Personal property
- Businesses
- Significant wetlands, inclusive of the Pacific Flyway
- Highways and railroads
- Water supply aqueducts and pumping plants

- River corridors that provide for fish and wildlife migration and for conveyance of flood flows (Sacramento, Mokelumne, Cosumnes, and San Joaquin rivers)
- Transmission lines (electric and petroleum)
- Deep-water Shipping
- Water and wastewater treatment plants
- Natural gas storage
- Water quality and water supply
- Western islands that help repel salinity
- Export water supply conveyance (Old River and Middle River)
- Agriculture
- Recreation
- Cultural, historical, and aesthetic assets

Some of these benefits are protected by Delta levees acting individually to prevent direct damage from flooding. Other benefits are protected by the levees functioning together to preserve the network of channels and land areas. Damage and interruption of service from critical infrastructure can affect the State's economy and public health and welfare.

The State of California has entrusted DWR as the agency with the responsibility for managing water flow through the Delta and for representing State interests in Delta levees. Reducing the chance of levee failure and flooding of these in-Delta and extended State Delta assets is the major function of DWR's flood management activities in the Delta through its FloodSAFE initiative.

3.2 DWR Mission and Goals

The importance of the Delta's water resources to the State of California is the reason for DWR's participation in Delta integrated flood management. DWR's mission and goals provide the foundation for continued DWR involvement in the Delta.

3.2.1 DWR Mission

The mission of DWR is:

"To manage the water resources of California in collaboration with others to benefit the State's people, and to protect, restore, and enhance the natural and human environments."

As used by DWR in its mission statement, the term “water resources” has a broad meaning that includes all aspects of California’s waters – surface water, groundwater, droughts, floods, water quality, water uses, and a wide array of strategies for water resources management.

3.2.2 DWR Strategic Business Plan Goals

DWR’s Strategic Business Plan (DWR, 2005) expands on the DWR mission by defining eight strategic planning goals:

1. Develop and assess strategies for managing the State’s water resources, including development of the California Water Plan Update.
2. Plan, design, construct, operate, and maintain the State Water Project to achieve maximum flexibility, safety, and reliability.
3. Protect and improve the water resources and dependent ecosystems of statewide significance, including the Sacramento-San Joaquin Bay-Delta Estuary.
4. Protect lives and infrastructure as they relate to dams, floods, droughts, watersheds impacted by fire and disasters, and assist in other emergencies.
5. Provide policy direction and legislative guidance on water and energy issues and educate the public on the importance, hazards, and efficient use of water.
6. Support local planning and integrated regional water management through technical and financial assistance.
7. Perform efficiently all statutory, legal, and fiduciary responsibilities regarding management of State long-term power contracts and servicing of power revenue bonds.
8. Provide professional, cost-effective, and timely services in support of DWR’s programs, consistent with governmental regulatory and policy requirements.

3.2.3 FloodSAFE Goals

Under the Strategic Business Plan Goals 3 and 4, the DWR has established the FloodSAFE Program. DWR’s FloodSAFE Implementation Plan (DWR, 2010) provides integrated flood management goals as follows:

1. **Reduce the Chance of Flooding** – Manage flood events to reduce the occurrence of floods that could damage California communities, homes and property, and critical public infrastructure.

2. **Reduce the Consequences of Flooding** – Take actions that will reduce the adverse consequences of floods when they do occur and allow for quicker recovery after flooding.
3. **Sustain Economic Growth** – Design the sustainable flood management system to facilitate continuing opportunities for prudent economic development that supports robust regional and statewide economies without creating additional flood risk.
4. **Protect and Enhance Ecosystems** – Improve flood management systems in ways that include habitat functions as a facility design parameter. Incorporate, protect, restore, and enhance ecosystems and integrate flood management with other public trust resources needs.
5. **Promote Sustainability** – Plan for social, economic, and environmental sustainability in structuring flood systems for improving public benefits and protection. Take actions that improve compatibility of the flood management system with the natural environment and reduce the expected costs to improve, operate, and maintain the flood management systems into the future, including ecosystem function and future flood management system expandability in the design.

3.3 Delta Legislation and Codes

The importance of the Delta and its levees to the State of California has been included many times in State legislation and codes.

Virtually all assets and attributes of the Delta are dependent upon flood protection provided by the levee system.

The Delta was given a legal boundary (Section 12220 of the Water Code) in 1959 with the passage of the Delta Protection Act. The 1992 Delta Protection Act refined the definition to provide primary and secondary zones within the previously defined legal Delta. The Primary Zone (about two-thirds of Delta area) was intended to remain relatively free from urban and suburban encroachment to protect agriculture, wildlife habitat, and recreation uses. Urban development in the Secondary Zone (about one-third of Delta area) was intended to include an appropriate buffer zone to prevent impacts on the lands in the Primary Zone.

3.3.1 References to Delta Importance

Water Code and the Public Resource Code repeatedly make reference to the uniqueness and importance of the Delta. A few examples follow:

- **Preserve the Delta essentially in its present form** – The Legislature recognized the uniqueness of the Delta and its invaluable resources in Section 12981 of the Water Code. It says that the physical characteristics of the Delta should be preserved essentially in their present form and that the key to preserving the

Delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands. Section 12981 of the Water Code reads:

“(a) The Legislature finds and declares that the delta is endowed with many invaluable and unique resources and that these resources are of major statewide significance.

(b) The Legislature further finds and declares that the delta's uniqueness is particularly characterized by its hundreds of miles of meandering waterways and the many islands adjacent thereto; that, in order to preserve the delta's invaluable resources, which include highly productive agriculture, recreational assets, fisheries, and wildlife environment, the physical characteristics of the delta should be preserved essentially in their present form; and that the key to preserving the delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands. However, the Legislature recognizes that it may not be economically justifiable to maintain all delta islands.

(c) The Legislature further finds and declares that funds necessary to maintain and improve the delta's levees to protect the delta's physical characteristics should be used to fund levee work that would promote agricultural and habitat uses in the delta consistent with the purpose of preserving the delta's invaluable resources.”

- **The Delta needs its levees to preserve its value as a place** – It is difficult to consider one Delta levee independently from others. While all Delta levees are not of equal importance, they all play a role in the system of channels and land areas that constitute the Delta. In addition to the coequal goals of restoring the Delta ecosystem and creating a more reliable water supply, the Delta Vision Task Force (2008) recognized the value of the Delta as a place. The Task Force concludes, “State and federal recognition of the Delta should support the Delta as a place – regardless of any other actions on the environment and water supply.”

Through follow-up legislation, Public Resources Code Sect 29702 further recognizes the unique cultural, recreational, natural resource, and agricultural values of the Delta:

“The Legislature further finds and declares that the basic goals of the state for the Delta are the following:

(a) Achieve the two coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

(b) Protect, maintain, and, where possible, enhance and restore the overall quality of the Delta environment, including, but not limited to, agriculture, wildlife habitat, and recreational activities.

(c) Ensure orderly, balanced conservation and development of Delta land resources.

(d) Improve flood protection by structural and nonstructural means to ensure an increased level of public health and safety.”

3.3.2 Evolution of Important Delta Legislation and Codes

The following is a chronology of important legislation and California Water Code (WC) sections for the Delta. Each has some influence on Delta flood management. Due to unique circumstances and issues in the Delta (e.g., land surfaces below sea level and levees that hold back water every day) and the State's interest in diverse benefits provided by Delta levees, the State provides financial assistance to local levee maintaining agencies for maintaining and improving levees.

- **1959** – Delta Protection Act – WC 12200-12220. Established a boundary for the legal Delta. The act was oriented toward protecting water quality in the Delta and protecting holders of Delta water rights, in part by preventing excessive withdrawals. It was oriented not only to protecting water uses within the legal Delta, but also for export to areas of water deficiency.
- **1960s** – Multiple Delta actions related to constructing State Water Project facilities, water quality control, navigation, and flood management. The two directly pertinent to flood management were:
 - 1960 – Corps completion of the Sacramento River Flood Control Project, terminating at the mouth of the Delta, with the State as non-federal partner
 - 1966 – Dedication of the Corps' San Joaquin River Flood Control Project, also progressing into and terminating within the Delta, with the State as non-federal partner
- **1973** – The Way Bill – WC 12980-12991. Directed DWR (working with the Reclamation Board; now CVFPB) to reimburse eligible local public agencies for a portion (50 percent) of non-project levee maintenance and improvement costs after satisfaction of specific deductibles and with specific limits. This was the beginning of the Delta Levees Maintenance Subvention Program. The initial appropriation of \$300,000 was reduced by Governor Reagan to \$200,000.
- **1976** – Nejedly-Mobley Delta Levees Act – WC 12225-12227 and 12987. Adopted DWR Bulletin 192-75 as a conceptual plan for preserving the integrity of the Delta non-project levee system. Authorized DWR to prepare detailed plans and specifications for levee improvements and report recommendations to the Legislature. Authorized DWR to proceed immediately with a pilot project

through an agreement with a local district, so long as the local district provided at least 20 percent of the costs. Appropriated \$150,000. Required maintenance projects (WC 12987) to be compatible with Bulletin 192-75. Appropriated \$200,000 for FY 1976-77 for projects under Section 12980-12991.

- **1982** – DWR issued Bulletin 192-82 “Delta Levee investigation” with alternative Delta levee plans. This bulletin was DWR’s report in response to the 1976 Act. The plans were developed cooperatively with USACE and cost estimates were provided. The USACE bare-bones plan (USACE, 1982) was indicated to have a 1982 cost of \$450 million, which would escalate to \$1.5 billion by completion. Recreation and wildlife enhancements were estimated to add 16 to 20 percent to these costs. The estimate for a complete rehabilitation of the Delta levee system was estimated to be \$930 million (cost in 1982 dollars) and escalate to \$3.4 billion by completion. The report preface highlights the major issue of “who pays” for legislative discussion and decision.
- **1983, 1986, and 1987** – Negotiations (following major floods in 1983 and 1986) by DWR with FEMA adopting the Flood Hazard Mitigation Plan (HMP; see Section 5.2 of this BRM for a description), including agreement on completion of the “short term levee rehabilitation plan” for non-project levees (implementation of the HMP geometry; see Section 5 for details) by September 10, 1991. The HMP geometry was developed as an interim step – an improvement over the then-current condition of many levees, but not adequate for long-term reliability. The HMP geometry and deadline for compliance was applicable to the specific reclamation districts (RDs) that had received FEMA disaster assistance and, per RD engineers, the deadline was met by most of those RDs.
- **1988** – SB 34 – The Delta Flood Protection Act of 1988 – WC Sections 12986 and following (amendments and additions) and WC Sections 12300 and following. Declared the Legislature’s intent to increase State financial assistance for Delta levees to \$12 million per fiscal year and established the Special Projects Program for the eight western islands and for the towns of Thornton and Walnut Grove. Annual appropriations were to be \$6 million for Subventions and \$6 million for Special Projects. Required that Subventions and Special Projects include provisions for protection of fish and wildlife habitat, as determined by the Department of Fish and Game, including “no net long-term loss of riparian, fisheries, or wildlife habitat.” Raised State cost sharing on Subventions Projects for non-project levees to 75 percent until January 1, 1999. Required that Subventions Projects be compatible with Bulletin 192-82. Allowed for advances of State funds. Required work agreements between State and local agency that indemnify the State. Required that the local agency apply for federal disaster assistance whenever eligible.
- **1991** – SB 1065 – WC 12306-12308 and Budget Act. Required increased cooperation among the Resources Agency, DWR, The Reclamation Board (now CVFPB), and Department of Fish and Game on habitat mitigation for Delta levee

projects. Reaffirmed the “no net long-term loss” of habitat policy. Made various budget appropriations.

- **1992** – SB 1866 – The Delta Protection Act of 1992– Public Resource Code (PRC) 29700 and following. Created the Delta Protection Commission. Refined the boundary of the legal Delta and established the Primary and Secondary zones. Many findings regarding uniqueness, statewide importance, need to preserve and protect the Delta and improve flood protection. Required development of a Resource Management Plan for the Primary Zone. Leaves land use authority over Secondary Zone in the hands of the counties and cities. The Legislature declares that it is a basic goal of the State to improve Delta flood protection to ensure an increased level of public health and safety.
- **1994** – SB 285 – PRC 29735, 2960 and following. Provided refinements to the Delta Protection Act, extending deadlines regarding the Resource Management Plan.
- **1995** – Assembly Joint Resolution No. 30 – Authorized CALFED. Delta levee integrity was one of CALFED’s four major objectives.
- **1996** – AB 360 – WC 12300 and following and WC 12980 and following. Made substantial improvements to the Delta Levee Maintenance Subventions Program and the Special Delta Flood Protection Projects Program. Reaffirmed intent to appropriate \$6 million per year to each. Extended the Subventions Program to Project levees in the Primary Zone, and it extended Special Projects to “other locations in the Delta” and to approximately “12” miles of levees on islands bordering Northern Suisun Bay from Van Sickle Island westerly to Montezuma Slough (In fact, the distance in levee miles from Van Sickle to Montezuma Slough is more nearly 20 miles.), and contained a provision to sunset the Delta Flood Protection Fund July 1, 2006. Reemphasized coordination with Department of Fish and Game to ensure no net long-term loss of habitat and initiated the requirement for habitat enhancement – expenditures must be “consistent with a net long-term habitat improvement program and have a net benefit for aquatic species in the Delta.” Required local public agencies to apply for federal disaster assistance whenever eligible. Extended a maximum of 75 percent State cost share on eligible Subventions cost reimbursement to July 1, 2006. Authorized emergency work with Delta Levee Program funds of up to \$50,000 per site and not exceeding \$200,000 per year, contingent on local cost sharing. Required DWR to “prepare and submit to the Board for adoption a Delta emergency response plan for levee failures.”
- **1996** – Proposition 204 – SB 900 – WC 78500. Safe, Clean, Reliable Water Supply Act. Total general obligation water bonds of \$995 million, including \$193 million to the Delta Improvement Account, of which \$25 million was for Delta Levee Rehabilitation, \$10 million was for South Delta Barriers, \$2 million for recreation, \$3 million for CALFED costs, \$60 million for CALFED/Bay-Delta/ecosystem/non-flow Regional Board Water Quality requirements, and \$93

million to the Central Valley Project Improvement Act subaccount for State actions and cost sharing complementing CVPIA activities.

- **1998** – SB 1075 – Refinements to the Delta Protection Act –PRC Sections 29729 and following. Authorized Delta Protection Commission (DPC) to act as facilitating agency for implementation of any joint habitat restoration or enhancement program. Extended life of DPC until January 1, 2010 (but this sunset provision was repealed by AB 2930 in 2000, giving DPC a continuing existence).
- **2000** – Proposition 13 (March Primary) – AB 1584 (1999) – Safe Drinking Water, Clean Water, Watershed Protection, and flood Protection Act. General obligation bonds of \$1.97 billion, including \$292 million for flood protection, of which \$30 million were for Delta levee rehabilitation.
- **2000** (August) – CALFED Programmatic Record of Decision was certified, including adoption of the Delta-specific PL 84-99 design as the base level of protection for the Delta levee system.
- **2002** – Proposition 50 (November) – Voter Initiative – Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002 – WC 79500 and following. General obligation bonds totaling \$3.44 billion, including \$825 million to implement CALFED, of which \$70 million were allocated to Delta Levee Restoration.
- **2002** – SB 1653 and AB 2683 – California Bay-Delta Authority Acts –WC 79400 – and following. Established the California Bay-Delta Authority to implement the CALFED Programmatic Record of Decision.
- **2005** – AB 1200 – Required DWR to consider potential Delta impacts of subsidence, earthquakes, floods, changes in precipitation, temperature, and ocean levels and a combination of those impacts. Required DWR and the Department of Fish and Game to identify, evaluate and comparatively rate the principal options for addressing those impacts.
- **2005** – SB 264 – Extended Delta Flood Protection Fund to July 1, 2008.
- **2006** – AB 798 – Delta Levee Maintenance. Declared intention of Legislature to appropriate available bond funds beyond the previously indicated amount of \$12 million per year (combined total) for the Subventions and Special Projects Programs. Extended Delta Flood Protection Fund and Subventions maximum State cost share of 75 percent until July 1, 2010. Extended authority to advance funds until July 1, 2010.
- **2006** – SB 1574 –Required Secretary of Resources to convene a multi-department committee to provide a Strategic Vision for a Sustainable Delta by December 31, 2008.
- **2006** – Proposition 84 – Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006. Provided nearly \$5.4 billion in bond funds for various resource management and water projects, including

\$800 million for flood management of which \$275 million was for Delta projects for levee maintenance and improvements in emergency response preparedness.

- **2006** – Proposition 1E – Disaster Preparedness and Flood Protection Bond Act of 2006. Provided nearly \$4.1 billion for flood-related planning and projects throughout the State, including \$3 billion for State-federal project levees and the Delta. The portion for the Delta has not been firmly set, although the Legislature has appropriated \$305 million for Delta projects so far. The “Bond Expenditure Plan” (DWR, 2007) allocated “a minimum of \$500 million to reduce the risks of levee failure in the Sacramento-San Joaquin Delta.”
- **2007** – FloodSAFE – Legislation that pertains to DWR/FloodSAFE and CVFPB activity and responsibilities in the Delta occurs in several contexts: 1) general (applicable to the whole State or the entire Central Valley), 2) specific to the State Plan of Flood Control (project levees), 3) specifically applicable to the whole Delta, and 4) specifically applicable to non-project levees in the Delta. The first two of these categories were significantly affected by the 2007 package of California Flood Legislation, which is summarized and then detailed in two DWR documents (DWR, undated, and 2009). The legislation that is more specific to the Delta was updated by the broad package of water legislation passed in 2009 and has also accumulated from more specific legislation over time. The summary for the Delta draws much detail from the current Water Code. The following paragraphs address each of the four topics in turn:
 - ***General FloodSAFE Legislation*** – The 2007 flood legislation package consisted of five bills – SB 5 and 17 and AB 5, 70, and 156 – plus a sixth bill (AB 162). Present flood management work is also significantly influenced by Propositions 84 and 1E passed in 2006. This legislation established a substantially modified approach to flood management in general. The bills required the following of the CVFPB and DWR:
 - Adopt a schedule for mapping areas at risk of flooding in the drainage areas of the Sacramento and San Joaquin rivers by December 31, 2008. (Added to Water Code Section 8612)
 - DWR is to provide notice to cities, within the Central Valley but not protected by project levees, of available maps and information relating to flood risk⁴.
 - Comment on the safety element of a new or updated general plan for each city and county located within the Sacramento and San Joaquin Drainage District. The CVFPB is required to provide a written response within 60 days. (Amended Government Code

⁴ Health and Safety Code § 9610.b

Section 65302 and Added Government Code Section 65302.7)

- Develop policies that assist the implementation of general plan guidelines. (Amended Government Code Section 65303.4)
 - Ecosystem restoration can be incorporated into CVFPB flood projects. The CVFPB has authority to collaborate with State and federal agencies regarding multi-objective flood management strategies. (Added to Water Code 8590)
 - The CVFPB can establish a system of mitigation banking by which credits may be acquired in advance for flood control work to be performed by the CVFPB, the DWR, or a local agency authorized to operate and maintain facilities of the State Plan of Flood Control. (Added to Water Code 8613)
 - Investigate and evaluate the feasibility of potential bypasses or floodways that would significantly reduce flood stage south of Paradise Cut⁵.
 - Propose updated flood protection requirements in the California Building Standards Code by 2009 for flood plains with flood depths exceeding 3 feet⁶.
- ***State Plan of Flood Control*** – The Central Valley Flood Protection Act of 2008 (enacted by SB 5) directs DWR and CVFPB to prepare and adopt a Central Valley Flood Protection Plan (CVFPP) by 2012. Per the DWR Summary,

“The CVFPP is to establish a system wide approach to improving flood management in the areas currently receiving some amount of flood protection from the existing facilities of the State Plan of Flood Control. In addition, the CVFPP is to include a recommended list of both structural and nonstructural means for improving performance and eliminating the deficiencies of flood management facilities, while also addressing ecosystem and other water-related issues. DWR shall develop a recommended schedule and funding plan to implement the recommendations of the CVFPP. The flood legislation establishes the 200-year flood event (flood with a 1-in-200 chance of occurring in any year) as the minimum level of flood protection to be provided in urban and urbanizing areas. The flood legislation also limits the State’s liability for developing and adopting the CVFPP to that already associated with the existing State Plan of Flood Control.”

⁵ Water Code § 9613.c

⁶ Health and Safety Code § 50465

Other specific requirements relative to the State Plan of Flood Control for either the CVFPB or DWR are:

- Advise the Legislature of the schedule for preparation of a status report on the State Plan of Flood Control by December 31, 2008. (Added to Water Code Section 9120).
 - Adopt the CVFPP by July 1, 2012, and update every five years subsequently. (Added to Water Code Section 9612)
 - Prepare by July 1, 2008, preliminary maps for 100- and 200-year flood plains protected by project levees and provide such maps or notice information to Central Valley cities and counties.
 - DWR is to prepare and the CVFPB approve (project) levee flood protection zone maps, indicating areas at risk of flooding three feet or deeper.
 - Beginning September 1, 2010, DWR is to provide yearly notices to owners of property in a (project) levee flood protection zone.
 - When a local flood maintaining agency is not able to operate or maintain project levees permitted by the CVFPB to acceptable standards, DWR or the CVFPB is authorized to form a maintenance area and take responsibility for the levee when in the best interest of the State. (Amended in Water Code Section 12878.1)
- ***The Delta as a Whole*** – Recognizing the specific intent of Propositions 84 and 1E to address the needs of the flood management system including the Delta and DWR's existing programs addressing the Delta, DWR has incorporated all its Delta flood management activities into FloodSAFE. Thus, funds for the Delta go beyond the State Plan of Flood Control to consider other needs, including vulnerable urban areas, vulnerable infrastructure, the reliability of water conveyance capabilities, as well as the needs of the Delta more broadly as a region.
 - ***Non-Project Levees in the Delta*** – The Delta Flood Protection Program (Subventions and Special Projects) is a FloodSAFE program and is specifically oriented toward maintenance and improvement of non-project and eligible project levees based on Water Code Section 12980 and following and Section 12310 and following. The legislative direction for this program was developed in four principal bills described above. These bills, including legislative declarations of the Delta's unique importance and statewide interests, clarify that the objective of preserving the Delta is for the enjoyment and benefit of the State, and the appropriations provided for that purpose have a direct result on what is done in the form of local assistance to Reclamation Districts for maintaining and improving the non-project levees.

- **2008** – SB 27 – Sacramento-San Joaquin Delta Emergency Preparedness and Response Act of 2008. Requires that Cal EMA, in cooperation with DWR, DPC, and a representative of each of the five counties form a Sacramento-San Joaquin Delta Multi-Hazard Task Force, is to develop an interagency unified command structure, coordinate the development of a draft emergency preparedness and response strategy, and develop and conduct an all-hazard emergency response exercise in the Delta. The period of performance for the Task Force was recently extended to January 1, 2013.
- **2009** – The Comprehensive Water Package. This is the most significant recent legislation for the Delta. Within that package, SB X7 1 addresses Delta governance and development of a Delta Plan. Key provisions include:
 1. Creating the Delta Stewardship Council, which is to develop a Delta Plan oriented towards meeting the coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The objectives inherent in these goals, as listed in Water Code section 85020 are:
 - (a) Manage the Delta's water and environmental resources and the water resources of the state over the long term.*
 - (b) Protect and enhance the unique cultural, recreational, and agricultural values of the California Delta as an evolving place.*
 - (c) Restore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem.*
 - (d) Promote statewide water conservation, water use efficiency, and sustainable water use.*
 - (e) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*
 - (f) Improve the water conveyance system and expand statewide water storage.*
 - (g) Reduce risks to people, property, and state interests in the Delta by effective emergency preparedness, appropriate land uses, and investments in flood protection.*
 - (h) Establish a new governance structure with the authority, responsibility, accountability, scientific support, and adequate and secure funding to achieve these objectives.*
 2. Restructuring the current Delta Protection Commission, reducing the membership from 23 to 15 members, and tasking the DPC with the duties of:
 - (a) Adopting an economic sustainability plan for the Delta, that is to include flood protection recommendations to State and local agencies.
 - (b) Submitting the economic sustainability plan to the Delta Stewardship Council for inclusion in the Delta Plan.

3. Establishing the Sacramento-San Joaquin Delta Conservancy to implement ecosystem restoration activities within the Delta. In addition to the restoration duties the Conservancy is required to:
 - (c) Adopt a strategic plan for implementation of the Conservancy goals.
 - (d) Promote economic vitality in the Delta through increased tourism and the promotion of Delta legacy communities.
 - (e) Promote environmental education about, and the public use of, public lands in the Delta.
 - (f) Assist in the preservation, conservation, and restoration of the region's agricultural, cultural, historic, and living resources.
- **2010** – SB 808 -- Delta Levee Maintenance. The sunset on the 75 percent maximum State cost share for the Subventions Program reimbursement of eligible costs was extended to July 1, 2013. Similarly, the sunset on the authorization to advance funds on current projects was extended to July 1, 2013.

3.4 Perspective on Individual Levee Importance

Many Delta levees protect multiple benefits (see Section 3.1). However, as benefits vary widely throughout the levee system, DWR recognizes that not all levees provide public benefit or are of equal importance and that legislative guidance, fund source, funding availability, local participation, and priorities will guide where State investments should be directed.

While all Delta levees are not of equal importance, most are important to some degree. For example, each island plays some role in preserving the water quality in the Delta by reducing tidal exchange. DWR is involved in studies to counter the ongoing salinity impact of the Franks Tract, flooded since 1938. It is extremely difficult to determine each island's impact on water quality if the island remains flooded. This is especially true with the cumulative effect if two, three, or more islands remain flooded in different combinations. The cumulative effect is likely to show a measurable impact on Delta water quality in the long-term.

Levees protecting large populations, water supply conveyance, major highways or other critical infrastructure hold high importance for the State. However, levees protecting agriculture, local water diversions, recreation, cultural resources, and other values are important to the Delta economy and to the Delta as a place.

Most maps of Delta assets simply show the locations of the assets, such as a line for the Mokelumne River Aqueduct or a major highway. Following is a series of maps that show a different perspective on the assets and which Delta islands and tracts are important for maintaining the assets:

- Figure 3-1 shows a typical depiction of the Mokelumne River Aqueduct – a line across the Delta. However, a failure of a levee on one of several islands or tracts

could negatively affect operation of the aqueduct. Figure 3-2 shows these islands and tracts as a different perspective on the information in Figure 3-1.

- A similar, but more dramatic, perspective is for major highways. Figure 3-3 shows highways in and near the Delta. Figure 3-4 shows the islands and tracts that would disrupt highway travel when flooded. Roughly a third of the Delta is important for highways.
- Figures 3-5 and 3-6 show similar information for railroads.
- Figures 3-7 and 3-8 show information for transmission lines.
- Figure 3-9 shows the islands that are critical for conveyance of export water supplies.
- Combining Figures 3-2, 3-4, 3-6, 3-8, and 3-9 into Figure 3-10 shows that most of the Delta islands and tracts are important for critical infrastructure. However, Figure 3-10 is not all-inclusive as it does not show islands and tracts important for population, shipping channels, agriculture, recreation, and other assets.

Therefore, for the purpose of DWR work on the Delta Levee Programs, most Delta levees provide some level of benefits of State interest. Funding decisions for the Delta levees program will be based on guidelines contained in individual proposals.

Figure 3-1 Mokelumne River Aqueduct

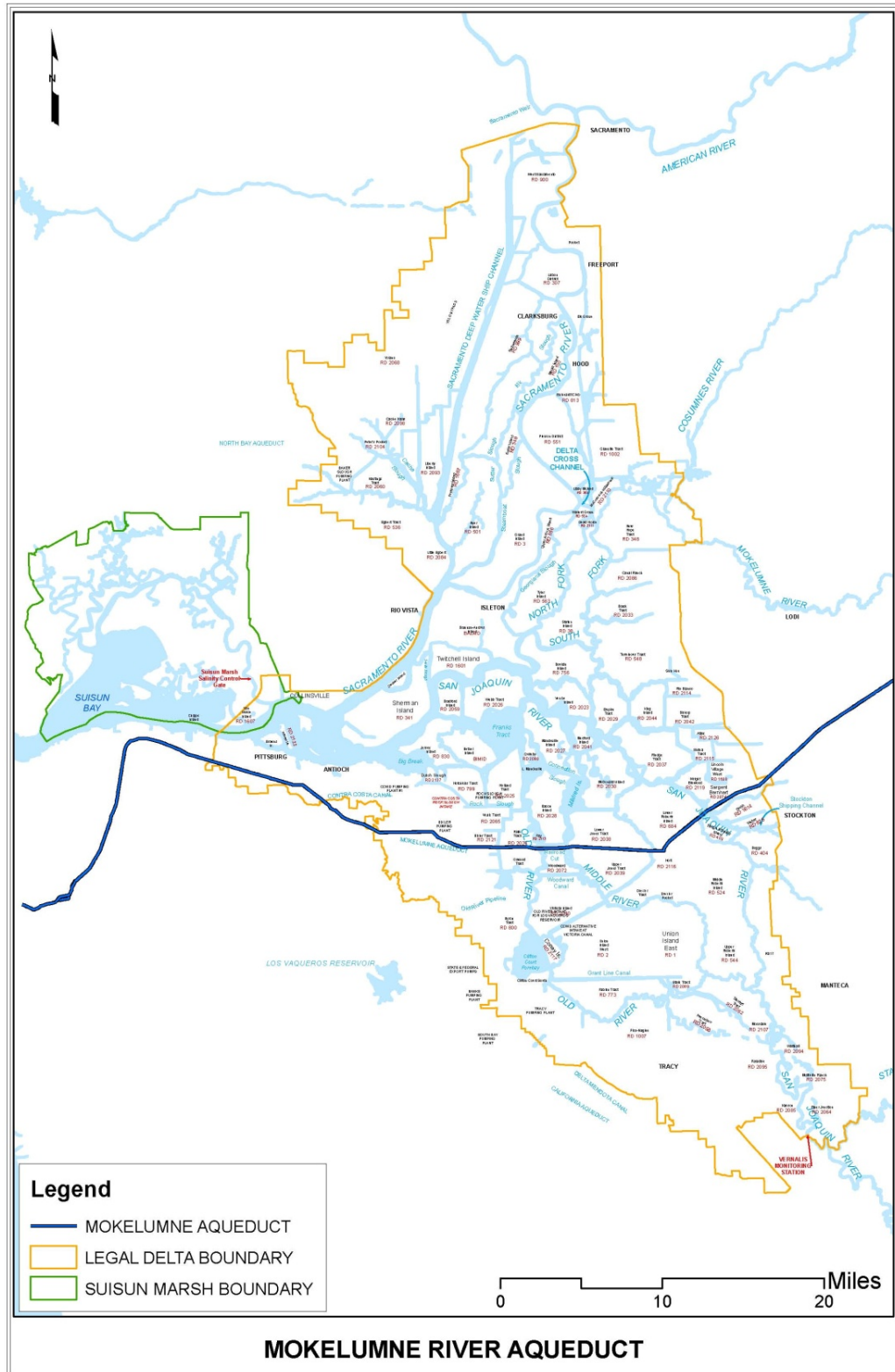


Figure 3-2 Mokelumne River Aqueduct – Delta Islands and Tracts

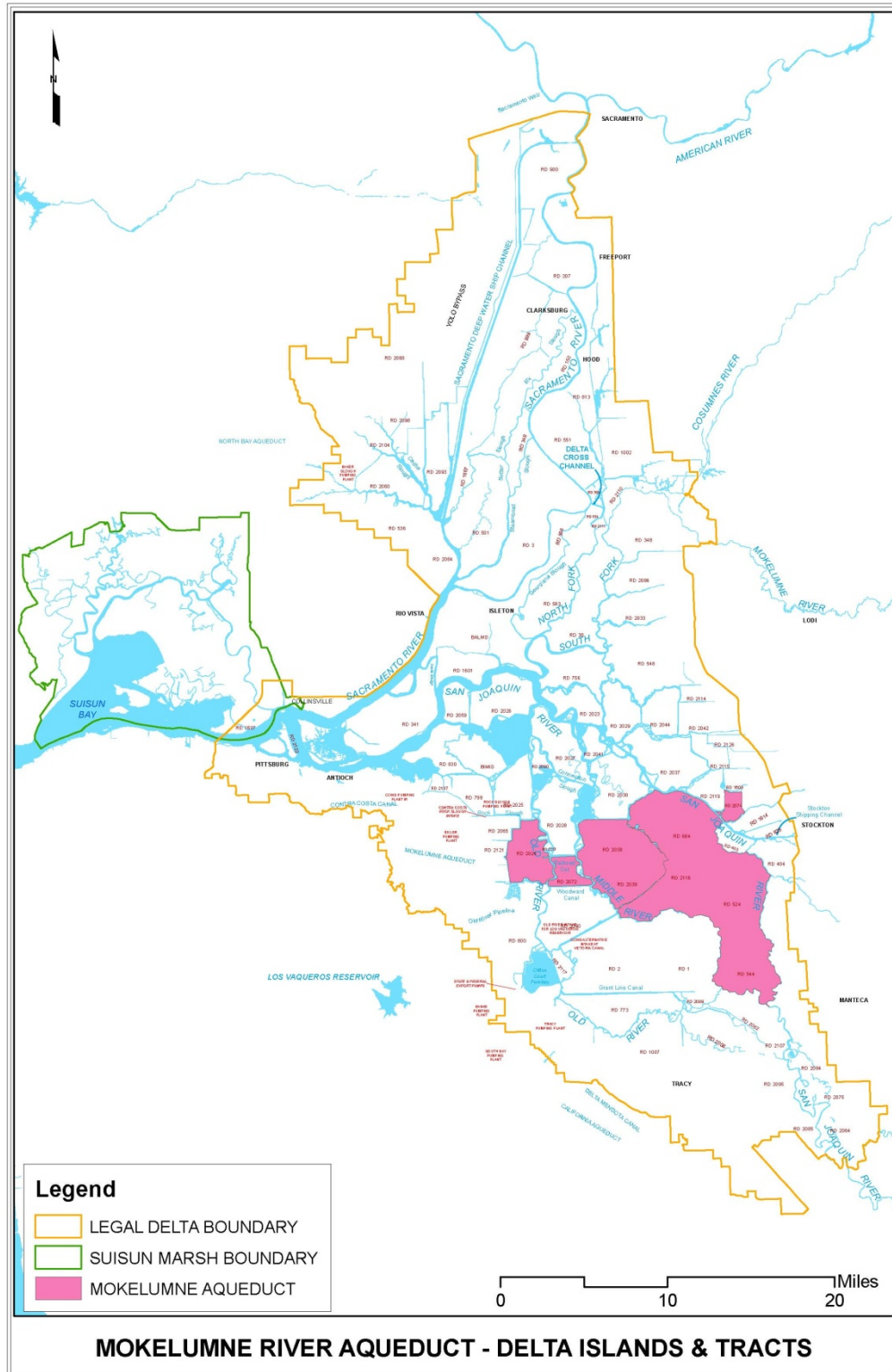


Figure 3-3 Major Roads

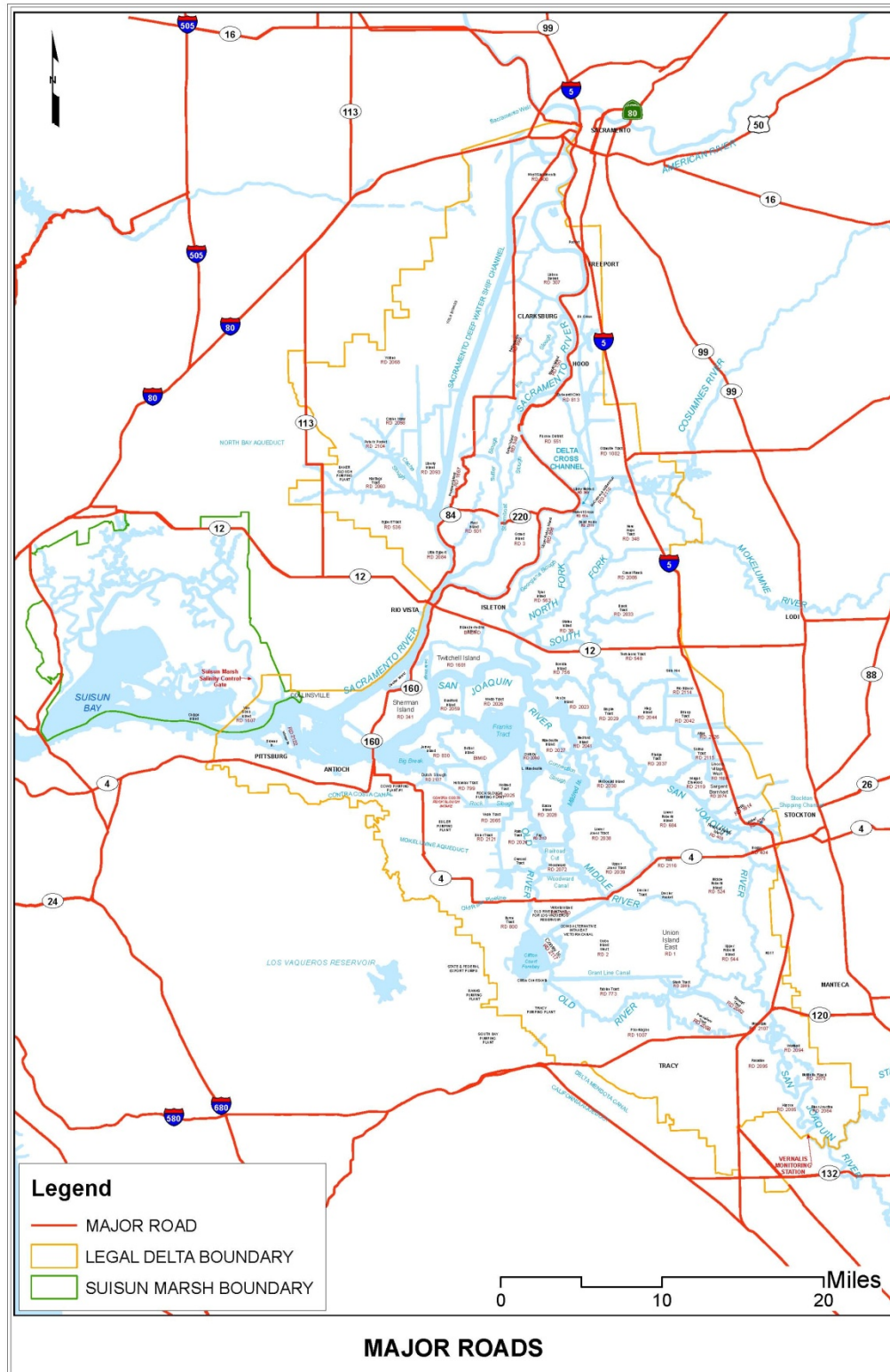


Figure 3-4 Major Roads – Delta Islands and Tracts

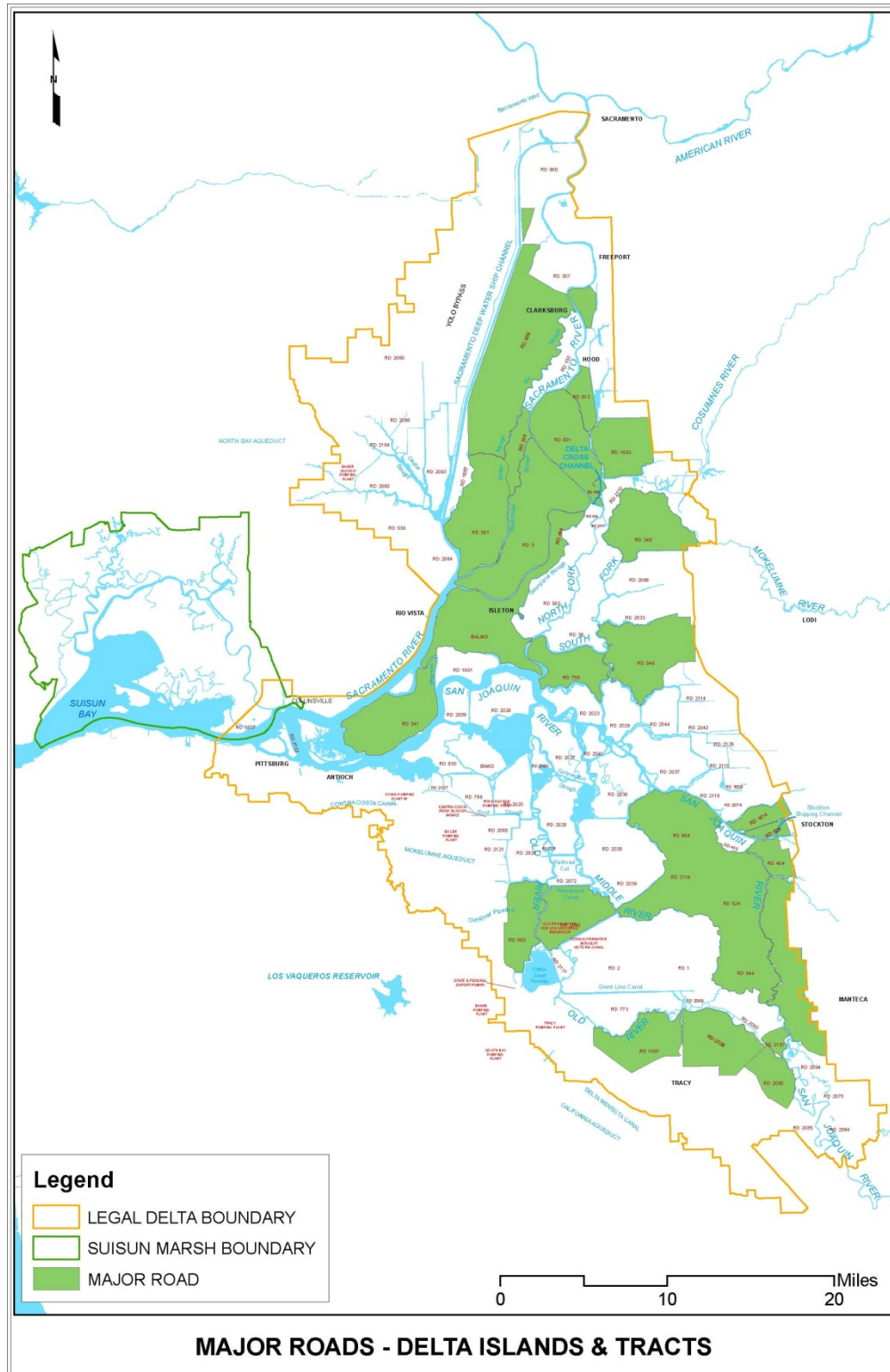


Figure 3-5 Railroads

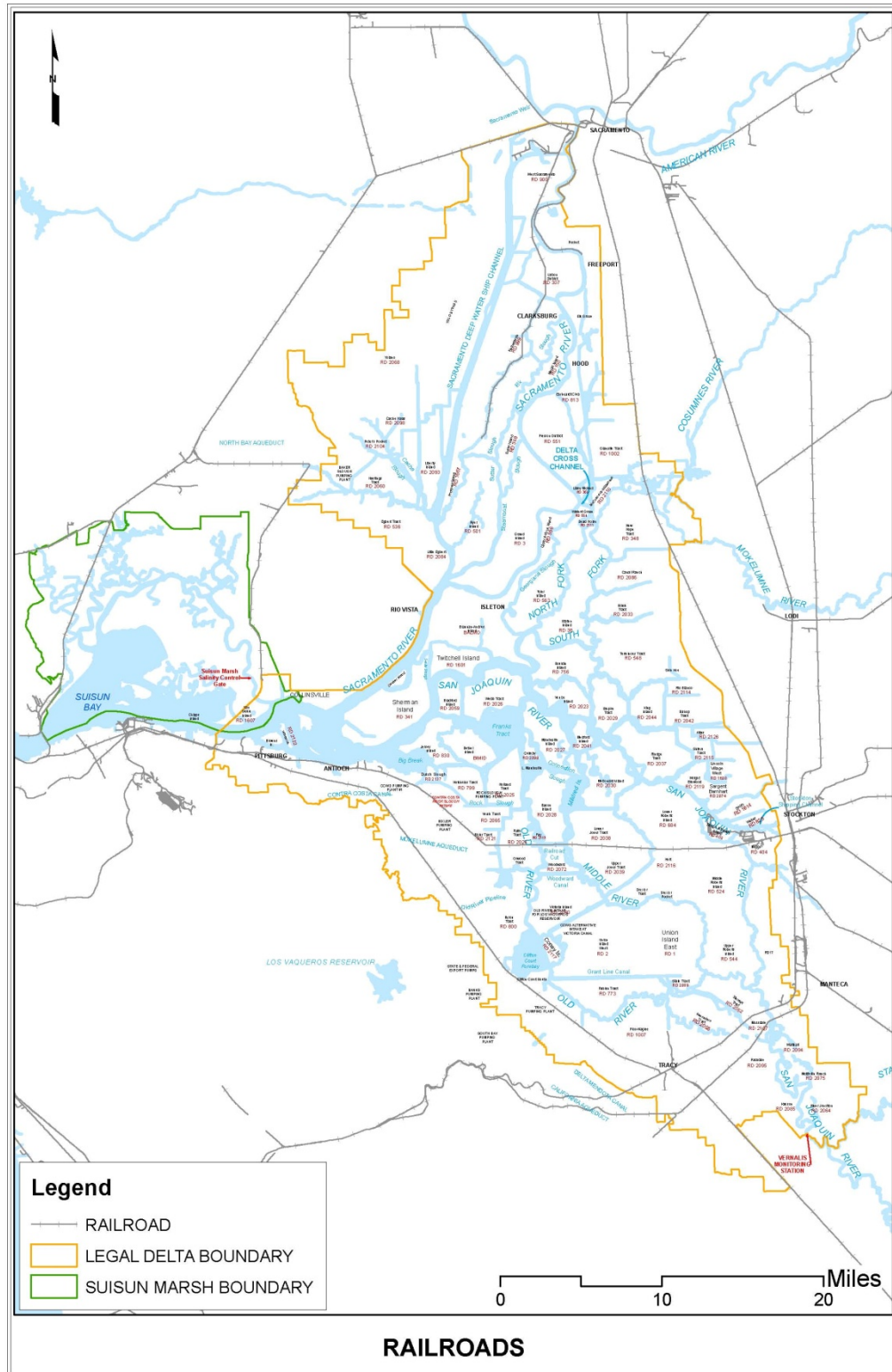


Figure 3-6 Railroads – Delta Islands and Tracts

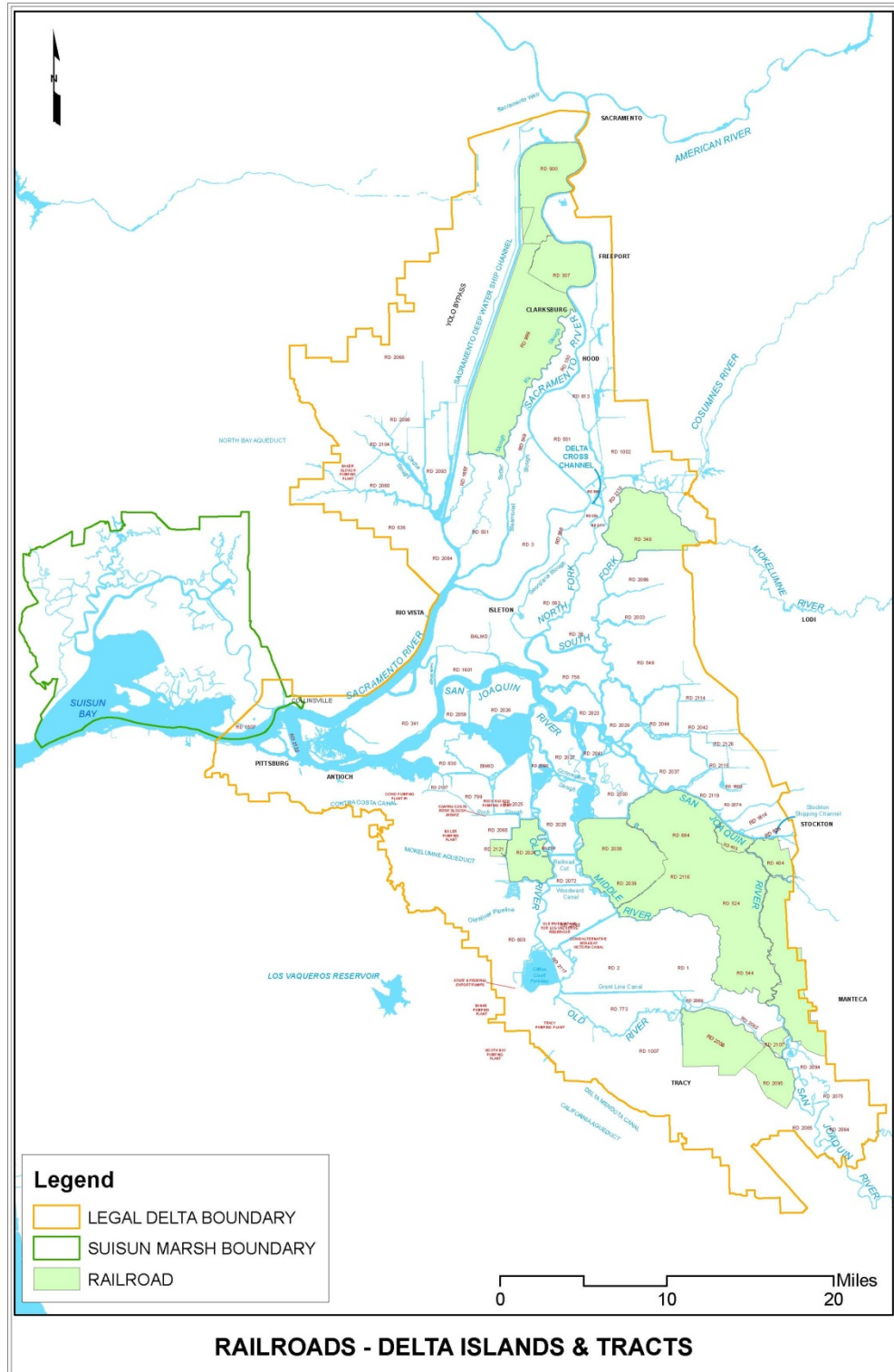


Figure 3-7 Transmission Lines

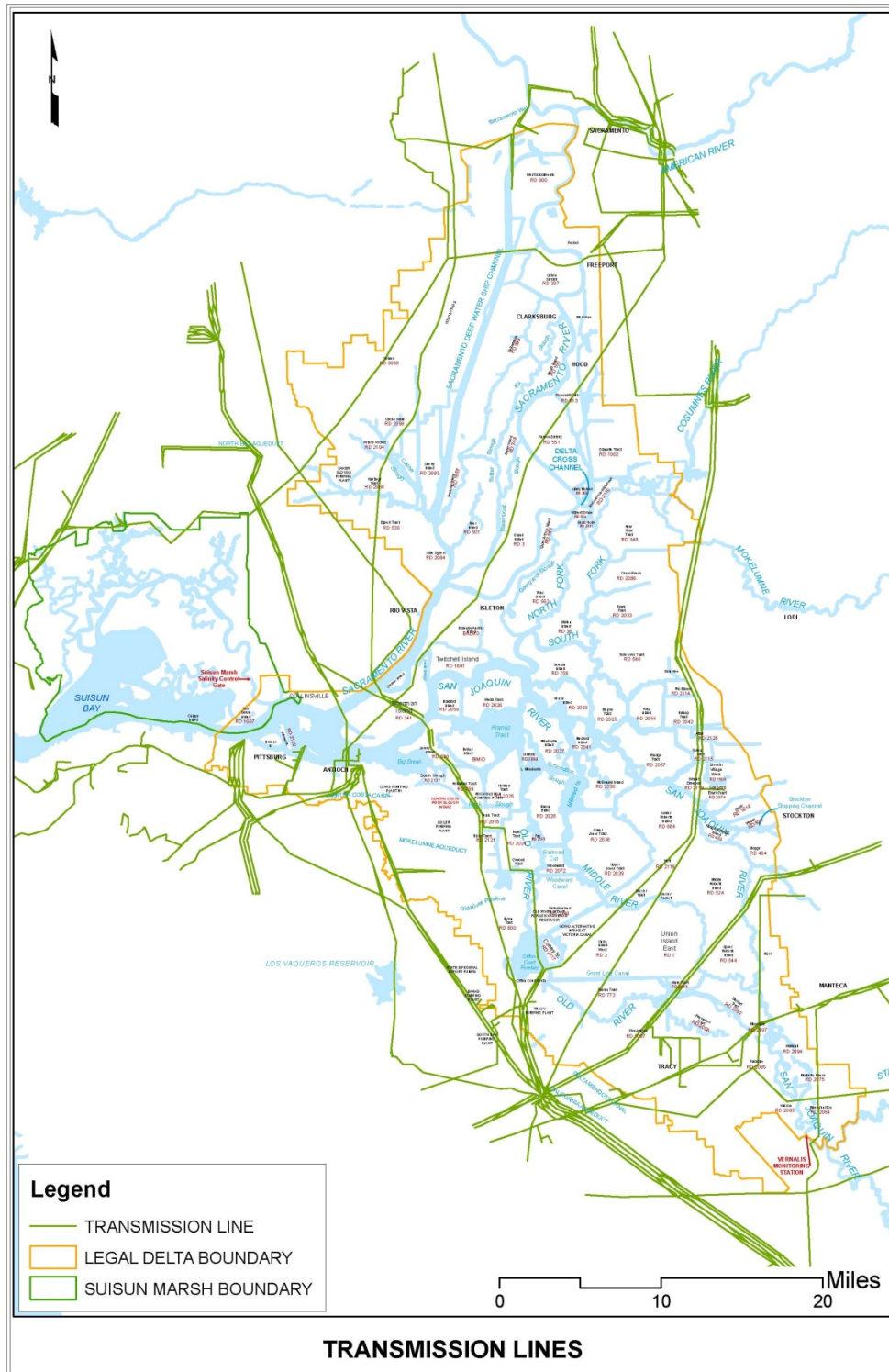


Figure 3-8 Transmission Lines – Delta Islands and Tracts

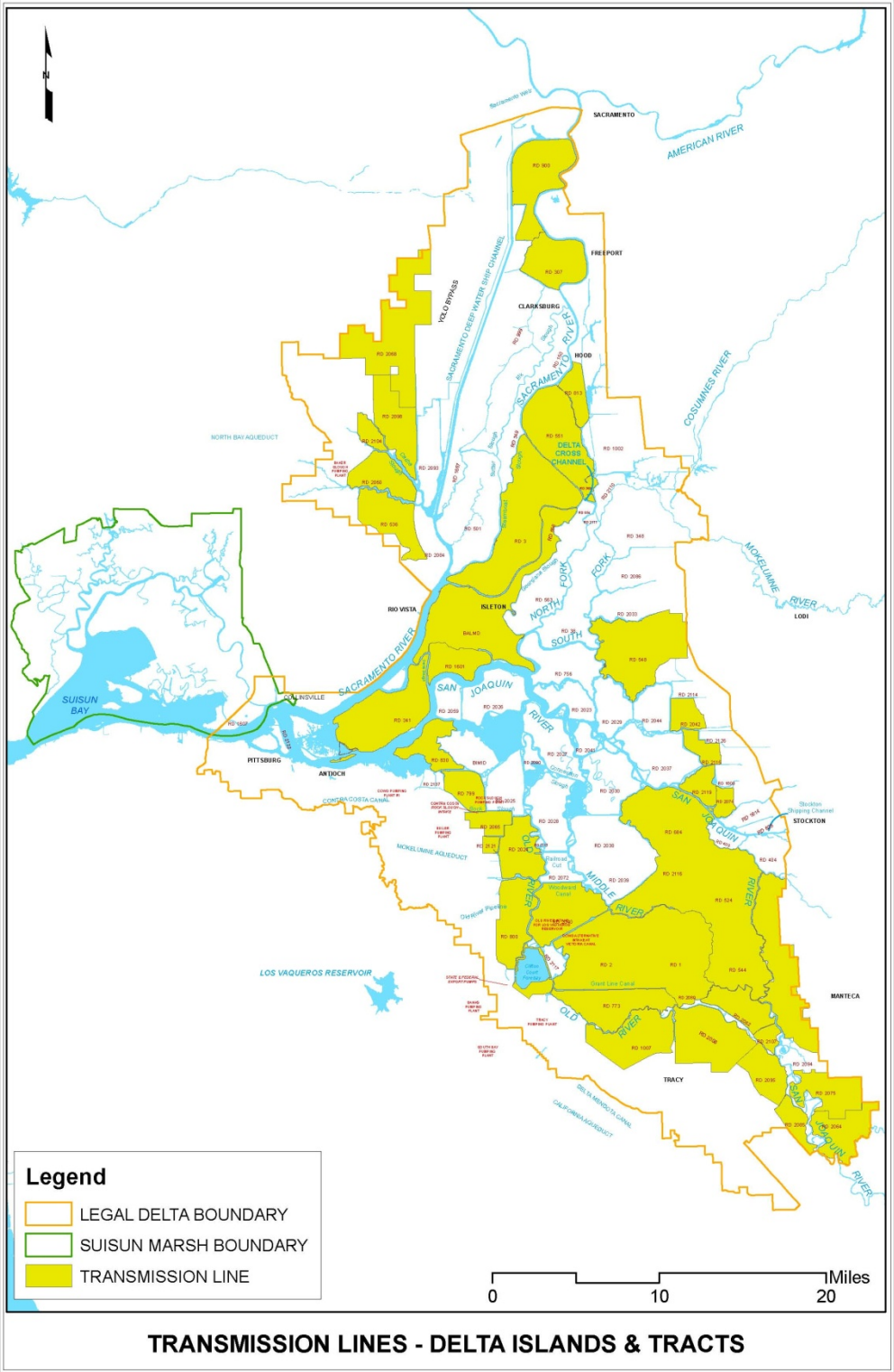


Figure 3-9 Conveyance for Export Water Supply - Delta Islands and Tracts

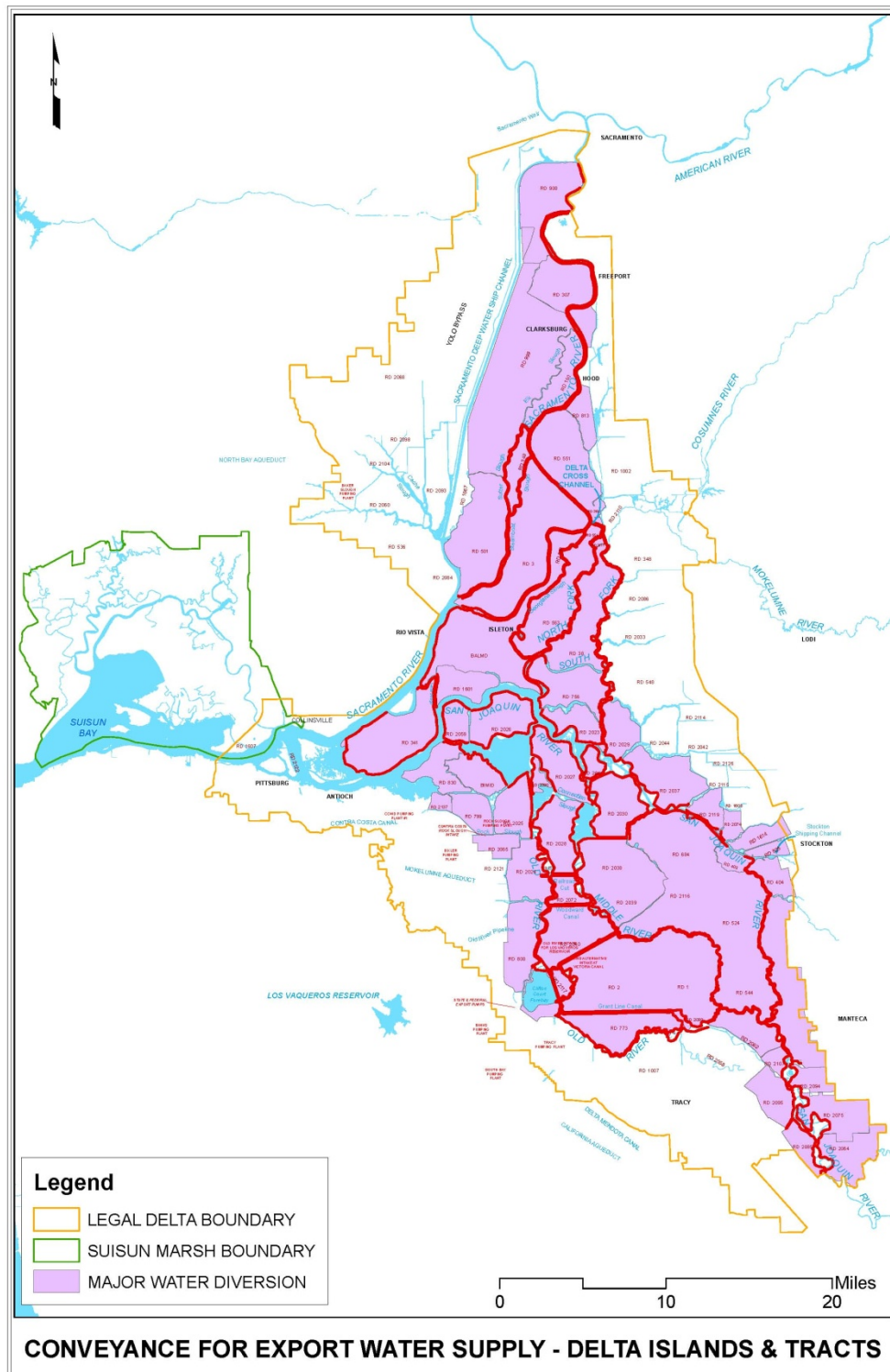
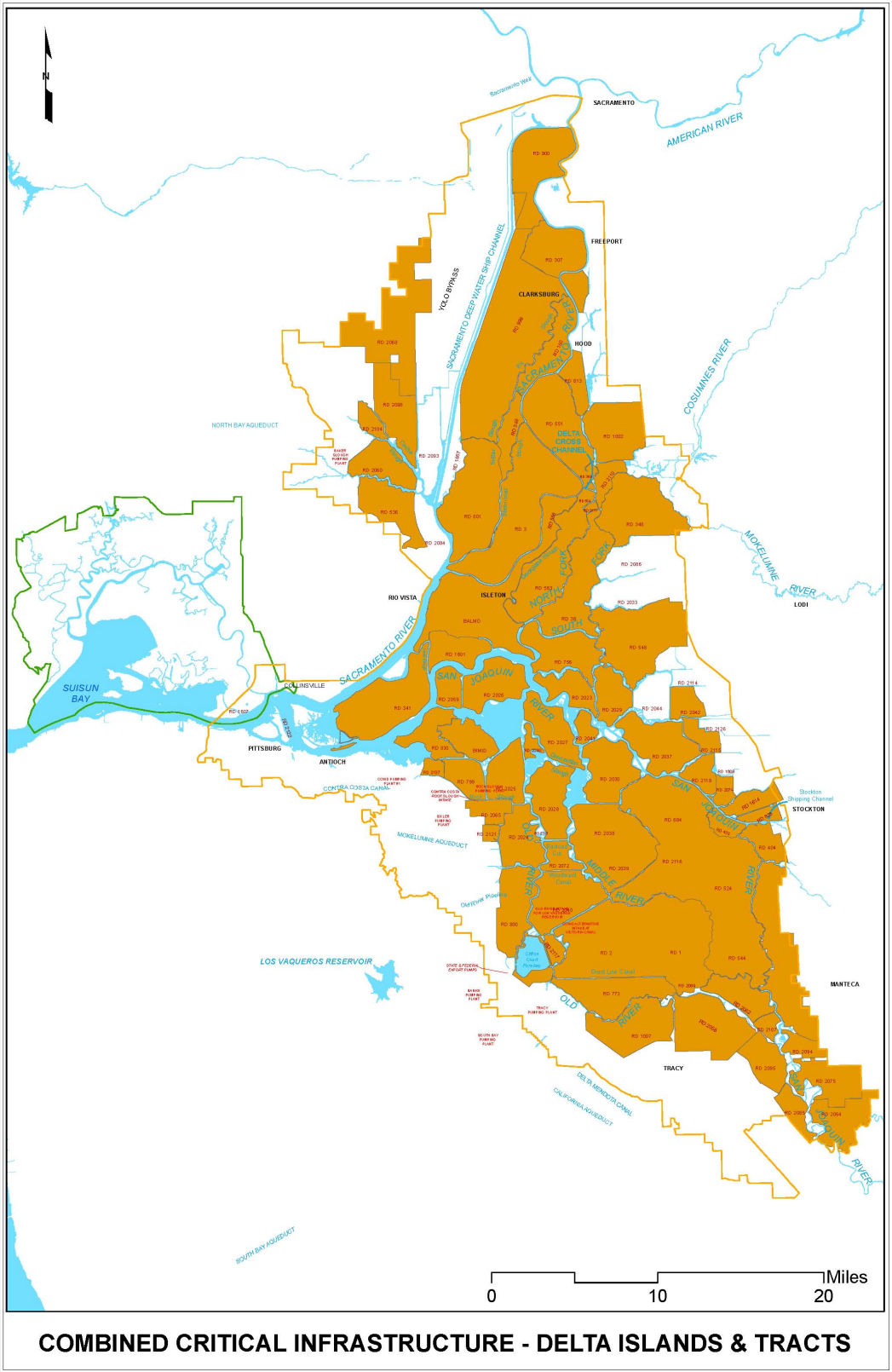


Figure 3-10 Combined Critical Infrastructure – Delta Islands and Tracts



4 FloodSAFE Delta Programs

Most FloodSAFE programs are relevant to the Delta.

4.1 Public Benefit from Privately Maintained Levees

The Water Code notes that while most of the Delta's levees are privately owned and maintained, they are being subjected to multiple uses that serve to benefit the public at large, resulting in added maintenance costs borne by adjacent land owners. Further, there is an urgent need for a higher degree of maintenance and rehabilitation throughout the Delta and the State has an interest in providing technical and financial assistance (Water Code 12982, et seq.).

This section states the justification for the DWR programs to provide a State cost share to support Delta non-project and eligible project levees.

4.2 Recent Delta Funding and Expenditures

DWR investments generally referred to as State grants, require cost-sharing that vary by type of investment. For some grants the cost sharing is with local agencies, others involve the federal government, and still others require a cost share from several beneficiaries which may include both the local agency and federal government. The beneficiaries of the Delta levee system include many interests: agricultural interests on each island, utility companies with mineral holdings and assets, highways, railways, shipping interests, and water contractors for the state and federal export system. The interests of each of these beneficiaries and more are served by the Delta levee system, and they are represented by individual RDs. The RD local to each island serves all beneficiaries as the agency responsible for levee operation, maintenance, and improvement, and receives state funds. This strategic policy is founded on the principle that local entities in the Delta represent the primary beneficiaries and remain responsible for the levees that protect their island. Local agencies are committed to keeping their levees in good condition; therefore, it is appropriate that incentives are provided and an assessment of all benefits or ability to pay is considered in determining the cost-share rates.

Propositions 84 and 1E provide significant State-appropriated funding, for FloodSAFE programs.

As of February 2010, the State has expended about \$166 million of the authorized bond funds. Table 4-2 shows the committed funds and expended portion by work task.

Table 4-2 Propositions 84 and 1E Delta Expenditure Report to February 2010

Tasks	Committed \$ Millions	Expended \$ Millions
Subventions Program	79	40
Special Projects	214	30
5-Year Plans	5	0
Contracts	13	10
Program Delivery	20	20
Emergency	110	15
Urban Levee Evaluation	13	13
Non-Urban Levee Evaluation	7	7
Sac Bank	6	6
Bond Servicing Cost	25	25
Total	492	166

Notes:

1. The amounts shown in this table are approximate and cover expenditures beginning with FY 07/08.
2. Contracts amount includes the interagency contract with DFG and work on LiDAR, USGS, and DRMS.
3. Project expenditures are shown on the Bond Accountability website.
4. Bond Servicing Cost is based on 3.5 percent of maximum available funds to the Delta programs.
5. Subventions Program commitments are based on approved plans by the CVFPB.
6. Special Projects commitments include FY 08/09 and FY 09/10 levee and habitat PSPs.
7. Future expenditures are not included in this table.

4.3 Delta Levees Maintenance Subventions Program

The Delta was reclaimed by reclamation districts (public agencies representing the interests of the owners of the Delta islands) by building and maintaining the current levee system at their own expense. These reclamation districts continue to work on the levees to protect assets on the islands. Over time, the State began to recognize that many of the assets protected by these levees are of significant State interest. Since the levees are now part of the infrastructure that conveys water across the Delta to the export pumps, and the levees protect other local and extended benefits the Legislature provided for the State to share in maintenance. The State makes investments in this maintenance through the DWR's FloodSAFE Environmental Stewardship and Statewide Resources Office's

(FESSRO) Delta Levee Maintenance Subventions (Subventions) Program. Levee upgrades can be funded under Subventions – indeed, it is the only State support mechanism available to most Delta islands. After FY 08-09, local agencies in the Delta also may now compete for grant funds to upgrade their levees under the Special Projects Program (see Section 4.3). However, these funds are available only to protect discrete and identifiable public benefits.

4.3.1 Provisions of Subventions Program

The stated intent of the Legislature for the Subventions Program, per Water Code Section 12981, is to preserve the Delta essentially in its present form, although legislation recognizes that it may not be economically justifiable to maintain all Delta islands. The Subventions Program has been the DWR's primary tool available to reclamation districts, and other eligible levee maintaining agencies, to minimize the risk of Delta levee failure. Each year's program is available to all eligible Delta public agencies. DWR has established Guidelines and Priorities (CVFPB, 2009) and specified eligible costs for this program including environmental mitigation and enhancement.

While the Subventions Program is primarily for non-project levees, some project levees qualify for the program. Within the Delta primary zone, project levees are currently eligible for grants from the Subventions Program as long as more than 50 percent of the island is protected by non-project levees. In the secondary zone, project levees are not eligible for Subventions funding. Maintenance of project levees that are not eligible for Subventions continues through the efforts of reclamation and levee districts. Portions of project levees (such as Maintenance Area 9 along the Sacramento River) in the Delta and SPFC channels will continue to be maintained by DWR.

DWR's current administrative provisions are outlined in Procedures and Criteria (DWR, 2011).

4.3.2 Prioritization of Funds

If, in any year, the total eligible costs incurred exceed the State funds available, the CVFPB will apportion the funds among those levees, or levee segments, identified by DWR as being most critical and beneficial for flood control, water quality, recreation, or wildlife, in accordance with the following funding prioritization method:

- a. The first priority for funding is for levee maintenance, fish and wildlife, and rehabilitation up to the Bulletin 192-82 standards (for geometry) associated with the existing land use at the time SB 34 was signed into law.
- b. If available funds are sufficient to fully fund work described above for the first priority, full reimbursement of claims will be made. When claims exceed available funds, full reimbursement of each claim will be made according to the categories listed below (in the order listed) until insufficient funds are available to fund a category. The claims in this latter category will be paid on a pro rata basis. Claims in lower categories will not be paid.

- Category 1: CVFPB-mandated top priority funding items.
 - Category 2: Plans that make special provisions for protection or enhancement of fish and wildlife habitat, recreation opportunities, or land use changes to reduce land subsidence or erosion. These provisions must be coordinated with DWR and/or DFG.
 - Category 3: Plans based on meeting the Short-Term Hazard Mitigation Standards.
 - Category 4: Plans based on meeting Bulletin 192-82 standards or PL 84-99 standards.
- c. The second priority for funding is for portions of an individual district's fiscal year work in excess of an average of \$100,000 per mile of all non-project and eligible project levees.
- d. The third priority for funding is for reimbursement of work in excess of Bulletin 192-82 standards.

4.3.3 Local Participation

The State has a significant interest in many Delta levees and contributes up to 75 percent of the qualifying costs for maintenance and improvement of the system. However, the actual work of maintaining and improving the levee is performed by the local agency. This system of working through the reclamation districts uses local knowledge of levee conditions, local administrative processes, and local labor and equipment to maintain the levees. State direct investment in non-project levees began with the Delta Levees Maintenance Subvention Program in 1973.

4.4 Delta Levees Special Projects Program

The Delta Levee Special Flood Control Projects Program (Special Projects), managed by DWR's FESSRO, was initiated in 1988 to address flood problems on islands of special State interest. It is detailed in Water Code Sections 12310 through 12318. Until FY 07-08, the funding for special projects was focused on the legislated scope of levee work on eight western Delta islands and the towns of Thornton and Walnut Grove though authorization has been available since 1996 to extend Special Projects funding to other Delta islands and to 12 miles of Suisun Marsh levees bordering northern Suisun Bay from Van Sickle Island west to Montezuma Slough. With the availability of bond funding from Propositions 84 and 1E, that broader scope is being implemented. Any local public agency that manages eligible project or non-project levees in the Primary Zone or non-project levees in the Secondary Zone is eligible to apply for Special Project funding. Special Project grant applications are received in response to Project Solicitation Packages (PSP) periodically offered by DWR to accomplish specific objectives of the department as discussed in the "Framework for DWR investments in Delta Integrated Flood Management."

4.5 Delta Flood Emergency Preparedness and Response

DWR's Division of Flood Management has several Delta-oriented programs underway that address Delta flood emergencies. DWR began work in 2006 to improve its ability to respond quickly and effectively to levee failures within the Sacramento-San Joaquin Delta, including simultaneous failures affecting multiple islands. The Delta Emergency Operations Concept Paper (DWR, 2007) was the initial product of this effort. A Delta Emergency Preparedness, Response and Recovery Plan (Delta EPRRP) that further clarifies DWR's response to Delta levee failure scenarios is being prepared.

In 2008, DWR stockpiled approximately 240,000 tons of rock at two locations; Rio Vista and Port of Stockton, for emergency repair of water conveyance pathways, to block channels to limit water quality impacts of salinity intrusion, and to facilitate movement of Sacramento River water to the export pumps in the event of large-scale, multiple levee failures that disrupt water exports.

A more detailed effort is underway (Delta EPRRP) to identify strategies that can be employed for a wide variety of potential levee failures. The study will also evaluate additional waterside transfer facilities for loading rock on barges and stockpiling additional rock and other repair materials within the Delta.

At the same time, DWR is working with Cal EMA, the USACE, and local agencies to coordinate efforts in planning for emergencies. Cal EMA along with the five Delta counties and DWR have also developed a multi-hazard planning strategy per Senate Bill 27.

4.6 Delta Research and Studies

A wide range of research and studies are periodically conducted in the Delta. Currently, DWR is involved in several ongoing evaluations: (1) subsidence reversal, (2) reuse of dredge material, (3) updating the 100-year floodplain, and (4) geotechnical analyses of urban and non-urban islands with project levees and others.

4.6.1 Subsidence Control/Reversal

DWR will continue with pilot and farm-scale studies, including cooperation with appropriate research organizations, to determine how to economically grow crops that help control/reverse subsidence. Given the large geographic extent of existing subsidence, it is important to find the most cost-effective means to reverse subsidence and effect a beneficial change on Delta property. DWR will continue with pilot projects on State owned land.

4.6.2 Beneficial Use of Dredge Material

DWR will continue existing programs to identify opportunities and facilitate permitting efforts to reuse dredged materials for the foreseeable future.

4.6.3 Urban Levee Evaluations

The highest priority for FloodSAFE levee evaluations has been on approximately 300 miles of urban levees in the Yuba City/ Marysville, Sacramento, and Stockton areas. In the Delta, these include West Sacramento, the east bank of the Sacramento River from Sacramento to Freeport, and the east bank of the San Joaquin River in the RD 17 area. A portion of these evaluations are in the Delta.

4.6.4 Non-Urban Levee Evaluations

Non-urban levee evaluations are focused on project levees and appurtenant (generally connected) non-project levees. In the Delta, this is primarily addressing additional levees along the Sacramento and San Joaquin Rivers. A portion of these evaluations are in the Delta.

4.6.5 Floodplain Evaluation

The general purpose of this effort is to improve the quality and accuracy of flood hazard data, models, and mapping available to local communities. More specific goals are to provide useful topographic, hydrologic, and risk data that support land use planning, emergency response planning, and flood risk notification. An additional result is compliance with the AB 156 requirement to map flood zones that are protected by project levees. This program is supportive of, and supplemental to, the FEMA-required remapping of flood hazard zones as part of the National Flood Insurance Program.

4.7 Other FloodSAFE Programs Affecting the Delta

4.7.1 Early Implementation Program

Early Implementation Program (EIP) Projects are important repair and improvement projects that are ready for implementation prior to completion of the CVFPP. This program addresses only facilities that are part of the State Plan of Flood Control (SPFC) (e.g., project levees) and essential non-SPFC facilities that are protecting the same urban areas, including repairs or improvements for urban levees. In the Delta, this includes specific Secondary Zone urban efforts in the Lathrop/Mossdale area (RD17), West Sacramento, and perhaps others such as parts of southern Sacramento and western Stockton. There are no urban areas (>10,000 or projected to grow to 10,000 population) in the Delta Primary Zone. EIP only provides for repairs or rehabilitation of non-urban levees – not improvements. The EIP will be superseded by a program to implement the CVFPP when the CVFPP is completed in 2012.

4.7.2 Central Valley Flood Management Planning

Central Valley Flood Management Planning is the major FloodSAFE planning program, focused on the State Plan of Flood Control facilities (i.e., State/federal project facilities) in the Central Valley. The initial version of the CVFPP is to be issued by DWR not later than January 1, 2012, and adopted by the CVFPB by July 1, 2012. In the Delta, it will address project levees and appurtenant non-project levees.

4.7.3 Central Valley Flood System Conservation Strategy

As a companion effort to the Central Valley Flood Protection Plan (CVFPP), DWR is developing the Central Valley Flood System Conservation Strategy (Conservation Strategy), which is a long-term strategic approach for DWR to (1) achieve the environmental goals and objectives of the Central Valley Flood Protection Act, (2) implement DWR's environmental stewardship policy, and (3) address public environmental expectations. The CVFSCS is to integrate environmental stewardship into the flood system planning and ongoing operation and maintenance while reducing environmental regulatory compliance challenges.

4.7.4 Statewide Flood Management Planning

As part of FloodSAFE California, DWR has initiated a comprehensive Statewide Flood Management Planning (SFMP) Program. A key outcome of the SFMP will be the development of a report, "Flood Future: Recommendations for Managing California's Flood Risk" that will be used to help guide California's flood risk management strategic policies and investment decisions in the coming decades. The timing of the initial version of the report will be coordinated with the release of the CVFPP in early 2012. Relative to the Delta, SFMP is the likely FloodSAFE vehicle that will address non-project levees and integrated flood management for the Delta as a whole.

4.7.5 Flood Corridor Program

The Flood Corridor Program funds competitive grants and direct expenditure projects with public agencies or non-profit organizations as the project sponsor and fund recipients. The projects all must reduce flood risk primarily using non-structural means. The flood risk reduction projects include acquisition, restoration, enhancement and protection of real property while preserving sustainable agriculture and conserving and/or enhancing wildlife habitat in and near flood corridors.

4.7.6 Emergency Erosion Repairs

Responding to flood damage in February 2006, the State initiated an emergency repair program to address some 250 critical levee erosion sites on project levees throughout the Central Valley. These include several sites in the Delta, especially along the Sacramento River. Many of these sites are being addressed cooperatively with the Corps of Engineers.

4.7.7 Flood Risk Notification

AB 156 (2007) requires DWR to provide written notice of potential flood risks to each property owner whose property is determined to be protected by State/federal levees (project levees), starting in September 2010 and annually thereafter. This includes areas in the Delta that are protected by project levees.

4.8 Local Land Use Planning Handbook

DWR's guide for land use planning, *Implementing California Flood Legislation into Local Land Use Planning: A Handbook for Local Communities* (DWR, 2010) describes how the 2007 California flood-related legislation affects cities' and counties' responsibilities related to local planning requirements, including general plans, zoning ordinances, development agreements, tentative maps, and other activities. The handbook was developed in recognition that cities and counties may find it challenging to identify and interpret which, how, and when codes apply to their jurisdictions.

4.9 Building Code Update

Responding to Health and Safety Code Section 50465, DWR developed and proposed for adoption updated requirements to the California Building Standards Code. The updated requirements apply to single-family homes and residential care facilities with six or fewer clients in areas protected by the facilities of the CVFPP where flood depths are anticipated to exceed 3 feet for a 200-year flood event.

5 Types of Delta Flood Management Work

The Department is involved in many flood management activities that affect water flow into and through in the Delta; some of these activities have multiple purposes and may not initially be recognized for their effect on flood management. Among these activities mentioned, but, not discussed below are development of predictive hydrology and hydraulic models, construction and operation of flood control dams and reservoirs, coordination of flood control releases, prediction of flood runoff, development of instrumentation for early warning, upkeep of the early warning system on CDEC, coordination of activities with Cal EMA, USACE, Department of Defense, coordination of river closures with the Coast Guard, executing requests for declaration of national emergency, implementing emergency operations under SEMS/NIMS to ensure proper coordination, and coordination with FEMA for reimbursement of State funds. These are just some of the activities that the Department undertakes in the normal course of business that have contributed to improved flood management in the Delta.

Specific activities related to the types of work that may be used to protect the State interests include:

5.1 Maintenance

Maintenance includes activities to keep levees in good working order so they continue to provide an expected level of readiness for high water events up to and including the design level of protection. This may be 1 percent annual chance of flood (0.5 percent annual chance of flooding for urban and urbanizing areas) or another level of protection. Maintenance is necessary to keep levee performance from deteriorating and may include major rehabilitation to address areas of weakness.

Routine maintenance is periodic work to keep the levee cross section and grade in conformance with its intended level of flood protection. In addition, repairs may be required when a levee is damaged or shows signs of distress (such as excessive erosion of levee embankments or seepage boils) in ways that indicate an increase in the chance of catastrophic failure.

5.2 Levee Improvements

Levee improvements are intended to increase the level of protection for an island/tract or increase the safety factor for a target level of protection. Since all levees in the Delta are not of equal importance, DWR supports funding based on guidelines discussed in the Framework for State Investments in Flood Management in the Delta.

Some of the possible levee geometric configuration and standards used in the Delta are shown in the following sections in the order of increasing level of flood protection.

5.2.1 Hazard Mitigation Plan (HMP)

HMP is a widely used geometric measure for Delta non-project levees. This configuration was established in 1983 through negotiations among the Federal Emergency Management Agency (FEMA), the State (primarily DWR), and the RDs as an initial, first-step improvement of the non-project levees. FEMA's primary interest was to avoid continued receipt of reoccurring claims for federal disaster assistance from the same RDs after minor floods or high-water events. The goal was to have Delta RDs with non-project levees that had submitted disaster claims improve their systems to the HMP geometry by September 10, 1991, five years after the agreement. Many of the Delta RDs managed to meet the initial deadline, and many have maintained their entire levee system up to the HMP geometry (including the requirement for surveys to document compliance). However, there are still a significant number that must complete some additional work to fully comply.

HMP Levee Cross Section

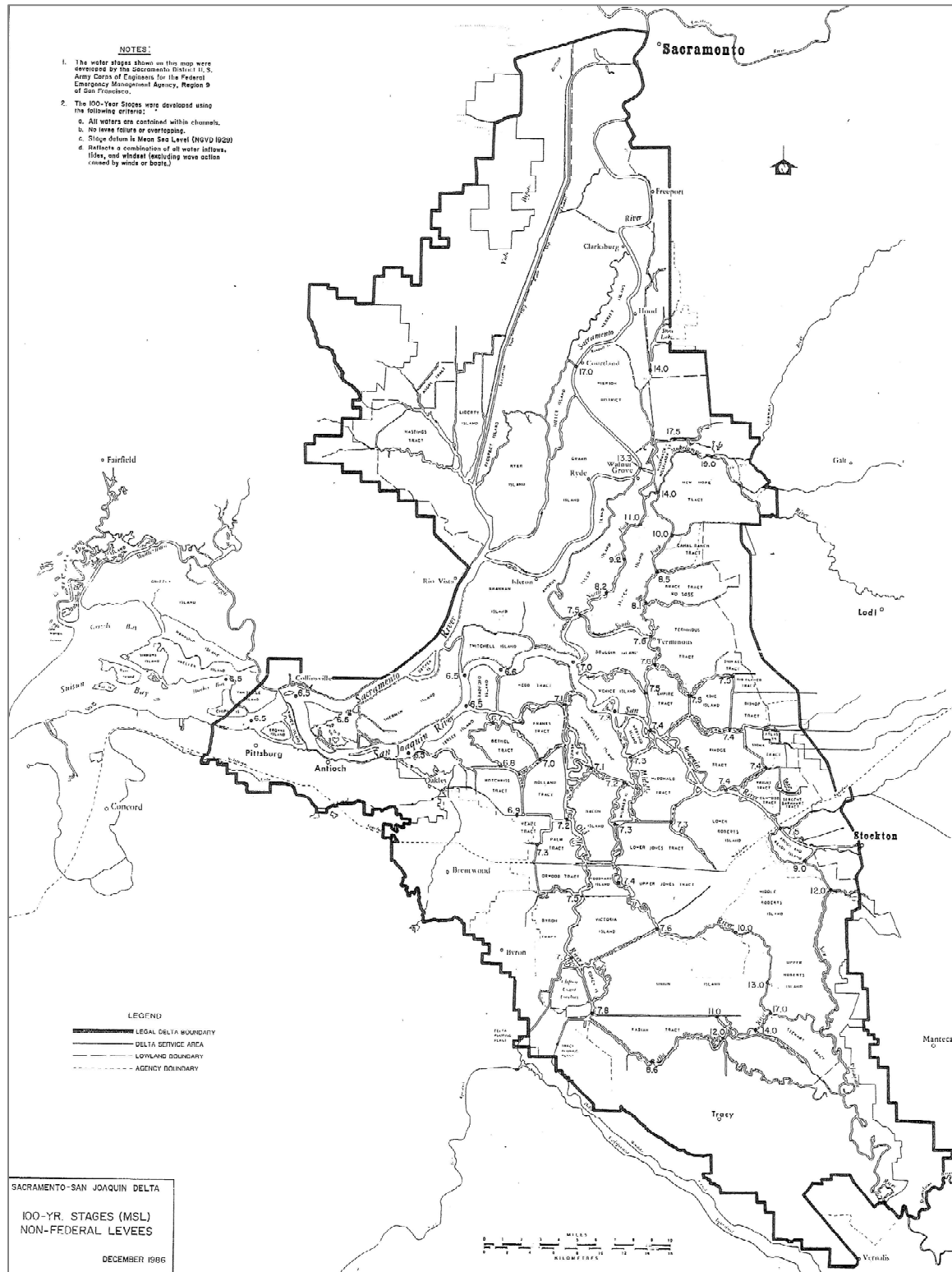
The HMP geometry provides for a minimum crest width of 16 feet, waterside slope of 1.5 horizontal on 1 vertical, landside slope of 2 horizontal on 1 vertical, and 1 foot of freeboard above the water level with 1 percent annual chance occurrence (100-year water stages) defined by the USACE (USACE, 1992). Figure 5-1 shows these estimated 100-year water stages in the Delta. Delta water levels associated with the 1 percent annual chance of occurrence were last updated in by USACE in 1992. Several times each year, DWR staff notifies Delta interests that the river stage will be above the monitor stage, and they should be ready to flood fight.

It is also important to recognize that 1 foot of freeboard for agricultural levees at a 100-year flood does not mean 100-year flood protection as common levee design practice calls for 3 feet of freeboard at project design flood. Also, the uncertainties of Delta levee foundations and unpredictability of Delta tide levels suggest that even with 3 feet of freeboard, the degree of flood protection would be less than the design flood frequency.⁷

When the HMP geometry was established, it was considered the minimum for levee cross section on an interim basis until higher long-term levels of improvement could be implemented. HMP provides for a levee cross section factor of safety against sliding of about 1.0, far lower than conventional levee standards. Considering that many Delta levees hold back water year round much like a dam, the HMP geometry is still regarded by DWR engineers as providing only the basic temporary level of flood protection that is required for federal disaster assistance eligibility. In addition, since the HMP geometry is simply a requirement for a levee cross section, there is neither geotechnical analysis nor allowance for material properties to determine the associated levee vulnerability.

⁷ Reference: Hazard Mitigation Plan, dated September 15, 1983, page 13.

Figure 5-1 100-YR Delta Water Stages



Source Corps of Engineers, December 1986

FEMA/Cal EMA MOU

While the original goal was to use September 10, 1991, as a deadline for qualifying levees to be eligible for federal disaster assistance, actual practice has modified this requirement of qualifying by a certain date. The actual practice considered which levees meet the HMP geometry at the time of the disaster. For example, if levees for two RDs both met HMP geometry at the time of a disaster, both should be eligible for federal assistance regardless if they met the 1991 deadline or not. Also the old version of the requirement did not apply to some districts. Due to this practice, there was a need to clarify the conditions required for maintaining HMP certification rather than continuing to rely on the old agreement.

FEMA and Cal EMA modified their memorandum of understanding (MOU) in 2010 (FEMA, 2010) to clarify the criteria to become or to remain eligible for FEMA public assistance. The MOU accepted the idea that priority actions which need to be performed by a RD may require work before all levees within a district meet HMP. For example, the local districts need to deal with all the risks they face, not just levee geometry, and they should not be forced to divert attention from areas with significant seepage problems when a small length of levee improvement on the back side of an island may be all that is needed to meet the HMP geometry. FEMA agrees that the district can be substantially compliant if an annual maintenance plan identifies non-compliant areas, shows that progress is being made, and submits to Cal EMA a plan for correcting those known deficiencies.

See Section VI of the FEMA/CalEMA MOU for details regarding public assistance eligibility.

5.2.2 Delta Specific PL 84-99

A design standard often used for non-project Delta levees is the USACE Delta-specific PL 84-99 standard, issued in 1987 and approved by the South Pacific Division in 1988 (see CALFED, 2000, Appendix A). This is a more robust design (targeting a static safety factor of not less than 1.25) and includes adjustments based on the depth of peat in the foundation.

PL 84-99 Levee Cross Section

The PL 84-99 guidance flattens the side slopes (3:1 to 5:1 landside and 2:1 waterside) from those used for the HMP geometry and increases freeboard above the 1 percent annual chance water level to 1.5 feet. This Delta Specific PL 84-99 cross section was determined by USACE to have a minimum factor of safety of 1.25. However, the freeboard of 1.5 feet above the 1 percent annual chance water level is still less than that required for FEMA accreditation for removal of an area from the 100-year floodplain. The PL 84-99 guidelines were recommended by CALFED as the base level of protection for Delta levees. The federal Water Resources Development Act (WRDA) of 2007 authorizes the Secretary of the Army to undertake the construction and implementation of levee stability programs or projects in the Bay Delta for such purposes as flood control, ecosystem restoration, water supply, water conveyance, and water quality objectives as outlined in the CALFED Bay-

Delta Program Programmatic Record of Decision (August 2000 ROD) and contains specific direction concerning justification of projects and programs.

Estimated Costs

Technical studies are not currently available to evaluate the cost of increasing most Delta levees to the Delta Specific PL 84-99 standard. However, some initial estimates have been made. The best available estimate was made by MBK Engineers for Delta Vision in 2008. The estimate to improve 635 miles of non-project levees to the USACE Delta Specific PL 84-99 standard is \$0.5 billion to \$1.4 billion. The lower estimate is based on levee embankment material obtained on each island, and the larger estimate is based on imported material. More detailed site specific technical studies are needed to improve the cost estimate.

5.2.3 *Bulletin 192-82 Delta Levee Standard*

DWR conducted studies of levee design criteria suitable for use in the Delta and published its results in 1983 as DWR Bulletin 192-82. Though similar to the USACE Delta-specific PL84-99 standard, Bulletin 192-82 includes design precepts that enhance the USACE Delta-specific standard. The Bulletin 192-82 cross section recommendations produces a levee that is designed for a water level with a 0.33 percent (1 in 300) annual chance of occurrence; and freeboard for levees protecting rural areas is 1.5 feet, while freeboard for levees protecting urban areas is 3 feet.

5.2.4 *Rural Project Levees*

These Delta rural project levees are part of the State Plan of Flood Control and generally provide 3 feet of freeboard above the design water surface (1957 profiles from USACE in the Sacramento River basin and 1955 profiles for the San Joaquin River basin) and 6 feet of freeboard above the design water surface for bypasses. The design water surface levels are generally for floods smaller than the 1 percent annual chance of occurrence. These levees generally do not meet FEMA standards for accreditation to remove the protected area from the floodplain as found in 44CFR 65.10.

5.2.5 *FEMA Accreditation*

These FEMA Accredited levees in the Delta provide 3 feet of freeboard above water level of 1 percent annual chance of occurrence. These levees include geotechnical designs to control through seepage and under seepage.

5.2.6 *Urban Levees*

In the existing levee system, urban levees provide varying levels of flood protection. As a practical matter most urban levees provide assurances of protection against a 1:100 flood event with 3 feet of freeboard. Recent changes in the law will require these levees to protect against an event with an average 0.5 percent chance of annual occurrence if cities or counties want to continue to approve development within the floodplain, with a minimum of 3 feet of freeboard. Specific standards are provided in the Interim Levee

5.2.7 Frequently Loaded Levees

Most riverine and upland levees are built in areas where the water course remains below the land surface of surrounding ground except for short periods of time once or twice a year. For some locations, including the Delta, levees are built to protect land that is normally below water level and the water course remains above the land surface of the surrounding ground most or all of the time. In these cases, the levees are frequently loaded, and in addition to considering the hydraulic loading, some of the levees may be designed to resist dynamic loading from credible earthquake forces in the vicinity of the levee. DWR is presently developing seismic criteria for use in urban levee projects receiving financial assistance through FloodSAFE.

5.3 New Flood Management Projects

New flood management projects including setback levees may be justified because they provide multiple benefits – for example, the new levee configuration may provide improved flood conveyance and enhanced riparian habitat. In addition, subsidence control/reversal, coupled with carbon sequestration, is considered beneficial for Delta lands that are currently at or below sea level. Investments in subsidence reversal are considered strategic for addressing levee stability problems and for restoring the Delta's habitat values.

An example of DWR integrating flood protection with other benefits is the North Delta Flood Control and Ecosystem Restoration Project which consists of flood protection improvements where the Mokelumne River, Cosumnes River, Dry Creek, and Morrison Creek converge. This same project will incorporate significant habitat enhancements that supplement and enhance the flood management function obtained through structural and non-structural measures. The project will reduce flooding and provide contiguous aquatic and floodplain habitat along the downstream portion of the Cosumnes River Preserve, near Grizzly Slough. Another example of incorporating habitat function into necessary structural repairs is the Twitchell Island setback levee. The resulting project provides significant habitat along the San Joaquin River and provides protection of the adjacent levee section. As part of the selection process for new flood management projects, each proposal will require an economic justification to show the benefits of the project exceed the State contribution beyond that required for HMP. For many new Delta projects, economic or environmental assets beyond those contained on the Island may provide the appropriate qualifying benefits.

5.4 Net Habitat Enhancement

DWR's flood management investments in the Delta are required to result in net habitat enhancement. DWR's goal is to enhance the Delta habitat in ways that allow species to thrive in sufficient numbers that DWR objectives in the Delta, including levee maintenance and repairs can be completed without significantly harming either habitat or

native species. Examples of such net habitat enhancement projects include the habitat developed on the northern tip of Decker Island.

5.5 Emergency Preparedness, Response, and Recovery

Emergency preparedness, response, and recovery include ways to identify and reduce the potential for and adverse consequences of flooding by taking specific actions before, during, and after a flood. The potential exists for catastrophic consequences during Delta levee failures. DWR funds and encourages emergency preparedness for the first responder, local agencies, and at the State, and federal levels, to enhance readiness to respond to a wide array of possible flooding scenarios. In consideration of the fact that levees in the Delta are the last line of defense against a daily flood threat in many areas, DWR positions Delta emergency assets, including funding and response within its authority, to provide early assistance to RDs, other first responders, and local agencies to prevent levee failure. DWR recognizes that it may not be feasible to participate in responding to or recovering all flooded areas after a major earthquake or large flood that damages multiple levees; therefore, DWR supports robust emergency response capability within the Reclamation District at the island level through the Subventions and Special Projects Program. DWR's planning and preparation for emergency response and recovery focuses on protecting:

- **Life, Safety, and Public Health** – Flood emergency response actions that help protect life, safety, and public health have the highest priority for DWR. During an emergency, levees protecting the largest population areas will receive first priority for State assistance. It should be noted that evacuation, rescue, and relocation of people are the responsibility of other agencies.
- **Critical Infrastructure** – Flood emergency response actions to protect critical infrastructure are the second priority for DWR since they affect many State interests, including the economy, and may contribute to protecting overall life, safety, public health and facilitate recovery.
- **Water Supply and Water Quality** – Water supply and water quality is a special case of critical infrastructure for which DWR has primary responsibility. Flood emergency response actions to secure in-Delta and export water supply and quality are a high priority to DWR. Failure of some levees has critical impact on the ability to use water in and export water from the Delta, which can affect public health and safety for over 25 million people who depend, in part, on water that flows through the Delta for their municipal and industrial supply. In addition, impacts to water supply and quality can affect agriculture on half a million acres in the Delta and 3 million acres of farmland outside the Delta. The loss or even reduction in Delta water supply or water quality will have a significant negative effect on the State economy.
- **Environment, Ecosystem, and Habitat** – During a flood emergency, DWR will include knowledgeable environmental staff in the SEMS organization to consider

ways that will minimize impacts on the ecosystem when taking emergency actions. In addition, ecosystem effects will be documented and evaluated to determine if mitigation is necessary. When it is determined that mitigation is required, DWR will fully mitigate for impacts resulting to the environment from DWR emergency response actions so long as these actions do not impair the effectiveness of the emergency response effort. During the recovery phase of an emergency, DWR will implement restoration and enhancement actions where feasible.

- **Property** – DWR will provide technical assistance to first responders and support emergency response efforts to keep islands or tracts from flooding so long as higher-priority needs do not require redirection of limited resources to other emergency locations.
 - **Public Property** - This is the second to lowest priority when responding to a flood emergency event. For islands and tracts where failure would have no impact on water supply, water quality or other critical infrastructure but where there has been an investment of public funds, there is a State interest in protecting the public investment. DWR will provide assistance and support so long as resources are available and higher-priority needs are being met.
 - **Private/Agricultural Property** – This is the lowest priority when responding to a flood emergency event. For islands and tracts that are privately owned and primarily agricultural where failure would have no impact on water supply, water quality, or critical infrastructure, DWR will provide assistance and support so long as higher-priority needs are being met and resources are available.

5.6 Planning and Evaluations

Planning and evaluations are included in all types of flood management work in the Delta. Each item of work, maintenance, levee improvements, new projects, habitat enhancement, and emergency actions include both a planning phase to determine appropriate actions and an evaluation phase to validate successes or change unsatisfactory outcomes. This is part of the Department's normal process. In addition, DWR conducts base studies of flood heights, sea level rise, seismic risk, and others to provide information for ongoing maintenance and operation of the levee system.

6 Agency Roles and Responsibilities in Delta Flood Management

While DWR has the primary responsibility for implementing the FloodSAFE initiative and resolving these key flood management issues, the tasks at hand are much too complex, costly, and time consuming for one agency to complete. The responsibility for improving and operating California's flood management systems is shared among multiple State, federal, and local agencies. Agency roles in Delta flood management activities depend on the type of activity being conducted. The Draft FloodSAFE Implementation Plan (DWR, 2010) shows the general FloodSAFE partnership of State, federal, and local agencies.

6.1 Local Agencies

The major local agencies involved in Delta flood management include the following:

6.1.1 Levee Maintaining Agencies

In the Delta, local agencies as defined in the CWC Section 12980(c) have primary authority for both maintenance of levees and flood fighting. Levee maintenance is provided by public levee districts, local government entities, private levee owners, and in some cases DWR. Collectively these agencies are referred to as Levee Maintaining Agencies or LMAs. Control of levee vegetation and erosion are among their main maintenance responsibilities. LMAs have primary responsibility for levee maintenance and flood fighting and are responsible for patrolling and protecting levees during high water. Also, encroachments on the levee are a major concern to LMAs since they can interfere with inspection, maintenance, and flood-fights. LMAs contract for engineering services to work on channel capacity, seepage, levee stability, or seismic loadings, and they cooperate with State and federal agencies for funding to plan, design, and construct improvements to components of the flood management system. Working with local planning agencies, the LMAs generally have input on management of the floodplains protected by their levees.

The Delta Local Agencies will work with the USACE as the non-federal sponsor of levee stability projects under authorization of PL 108-361. They will also work with DWR to respond to proposal solicitations and design, implement, operate, and maintain levee projects that may qualify for funding under Subventions, Special Projects, Urban Levee Evaluations, Non-urban Levee Evaluations, Early Implementation Program, and other FloodSAFE Programs.

6.1.2 Emergency Responders

Local governments and agencies within the Delta (counties, cities, LMAs, water agencies, special districts, and private levee owners) are the first responders during a

flood emergency. Local agencies use flood forecast and alert information prepared by the State-Federal Flood Operations Center supplemented by local levee patrols. DWR may provide technical assistance to local agencies on how to establish levee patrols, establish flood fight operations, investigate flood incidents, and coordinate requests for emergency assistance. DWR will also provide personnel and resources for flood fighting efforts to local agencies when the resources (personnel, equipment, materials, and finances) of a local agency are exhausted in accordance with standard Standardized Emergency Management System practice.

It should be noted that evacuation, rescue, and relocation of people are the responsibility of public safety agencies such as police, fire, or Sheriff's departments.

6.1.3 Reservoir Operators

Many local reservoirs upstream of the Delta were built for water supply and also provide flood control storage. Reservoir operators manage the storage and outflow during high runoff to the reservoirs to control downstream flows. Operation of these reservoirs along with other State and federal reservoirs is a critical part of responding to flood emergencies by keeping flows within channel capacity.

6.2 State Agencies

The major State agencies involved in Delta flood management include the following:

6.2.1 California Emergency Management Agency

Cal EMA ensures that the State is ready and able to mitigate against, prepare for, respond to, and recover from the effects of emergencies that threaten State interests, including lives, property, and the environment. During a flood emergency Cal EMA coordinates the emergency activities of all State agencies. The agency will coordinate the integration of federal resources into State and local response and recovery operations, including FEMA's pre- and post- disaster mitigation grants. It will also coordinate FEMA's Repetitive Flood Loss Program within the National Flood Insurance Program (NFIP), Flood Mitigation Assistance Program, Pre-Disaster Mitigation Grant Program, and Hazard Mitigation Grant Program.

The State Emergency Plan provides a consistent, statewide framework to enable State, local, tribal governments, federal government, and the private sector to work together to mitigate, prepare for, respond to and recover from the effects of emergencies regardless of cause, size, location, or complexity.

The plan is available at www.calema.ca.gov.

6.2.2 DWR

DWR is the lead for development and implementation of the State assets used in a flood response effort. It is responsible to develop and implement flood fight efforts. DWR will partner with local and federal agencies to conduct this work and to provide cost sharing.

DWR is a team member at the State-Federal Flood Operations Center during a flood emergency and assumes the lead State agency role in flood emergency response.

6.2.3 Central Valley Flood Protection Board

The mission of the CVFPB (formerly The Reclamation Board) is to control flooding along the Sacramento and San Joaquin Rivers and their tributaries in cooperation with the USACE and local sponsors. DWR performs the flood-related technical work in support of the Board's mission in the Central Valley. The CVFPB serves as the non-federal sponsor for the SPFC in the Central Valley. Therefore, with DWR's support, the CVFPB has a responsibility for resolving all the key flood management issues. The CVFPB participates with the USACE under PL 84-99 to restore or repair flood-damaged works after a flood. Under this program the Board provides the USACE with the necessary rights-of-way and relocations. In its regulatory authority, the CVFPB has a major role in preventing incompatible encroachments and controlling other encroachments to levees by issuing encroachment permits. The CVFPB is scheduled to approve and adopt the final CVFPP, which will set the path for major flood system improvements, by July 1, 2012.

6.2.4 California Department of Fish and Game (DFG)

DFG has both a regulatory and a support role in the Delta. With the implementation of the Delta levees program, DFG assures no net long-term loss of habitat occurs as a result of program work. It is a cooperating agency in implementation of habitat enhancement projects and is an integral partner assisting DWR in its environmental stewardship responsibilities. Due to the habitat value of the riparian corridor along many of the flood channels, DFG is involved in seeking ways to avoid habitat impacts, developing mitigation measures, and permitting flood management activities that can affect this habitat. DFG provides input on opportunities for enhancing the habitat value of floodplains. Activities that can especially alter the riparian habitat value include work to increase channel capacity, levee and bank erosion repairs, and vegetation control. During flood emergencies, DFG works with DWR to facilitate necessary emergency actions and to minimize affects on the ecosystem. DFG works with federal resource agencies on mitigation strategies, including banking opportunities and conservation plans for use during flood system improvements. DFG provides input and review of environmental documentation under the California Environmental Quality Act (CEQA) and permitting under California Endangered Species Act and Fish and Game Code 1600 *et seq.*

6.2.5 Delta Stewardship Council

The DSC is an independent agency of the State charged with developing a Delta Plan for providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem (see Section 7-2). As currently written, the Delta Plan (Plan) requires all project proponents to certify that their projects are compatible with the plan and the DSC has an appeal process to deal with exceptions and challenges. The Delta Plan and DSC will have a major effect on future flood management projects in the Delta.

6.2.6 Delta Protection Commission

The mission of the DPC is to adaptively protect, maintain, and where possible, enhance and restore the overall quality of the Delta environment consistent with the Delta Protection Act, and the Land Use and Resource Management Plan for the Primary Zone. This includes, but is not limited to, agriculture, wildlife habitat, and recreational activities. The DPC is preparing the Delta Economic sustainability Plan that will define economic interests and propose methods to sustain the Delta in the future. The ESP is expected to provide insight, considerations and methods to determine the benefits of future flood management projects in the Delta. The goal of the Commission is to ensure orderly, balanced conservation and development of Delta land resources and improved flood protection.

6.3 Federal Agencies

The major federal agencies involved in Delta flood management include the following:

6.3.1 Corps of Engineers (USACE)

For the Delta Islands and Levees Feasibility Study (DILFS), California Project, the USACE will be DWR's prime partner for technical work on studies, levee evaluations, and designs and reviews. DWR will be the non-federal sponsor for this DILFS project and will work with USACE in resolving all the key flood management issues in the table. USACE is working on updating the hydrology and hydraulic models for the Central Valley watershed, including incorporation of hydrologic changes due to climate change. Once complete, data from these studies will be used to update Delta Hydrology and Hydraulics. These models will be used to determine existing and future channel capacity needs.

USACE is working in the Delta with local agencies to implement levee improvement projects under authority of PL 108-361. DWR may provide funding to the local agency to facilitate levee improvements, provided no additional liability accrues to the State.

During a flood emergency when the nature of the emergency exceeds the capabilities of State and local interests, USACE may provide assistance under Public Law 84-99 to save human life, prevent immediate human suffering, or mitigate residential and commercial property damage. A major portion of USACE work will involve reviewing proposed projects to assure they meet design standards and to certify levees that meet these criteria. USACE is a team member at the State-Federal Flood Operations Center during a flood emergency.

USACE also has regulatory jurisdiction, primarily under the following three authorities: (1) Section 404 of the Clean Water Act for the discharge of dredged or fill material in waters of the United States (33 USC 1201 et seq.) (Section 404), (2) Section 10 of the Rivers and Harbors Act for working in navigable waters (33 USC 403) (Section 10), and (3) Section 14 of the Rivers and Harbors Act of 1899 (33 USC 408) for the alternation of a federal project (to include sea wall, jetty, dike, levee, wharf, pier, or other work) (Section 408).

6.3.2 Federal Emergency Management Agency (FEMA)

FEMA will continue to partner with DWR to provide accurate flood hazard maps, develop and maintain a GIS database of California levees and flood control structures, provide technical outreach to communities and citizens on floodplain management issues, and support the NFIP. FEMA's flood hazard information is often the basis for community planning for floodplain management. For levees to be accredited, FEMA must be satisfied that levees meet standards for channel capacity, seepage, erosion, maintenance (vegetation), stability, and seismic loadings. FEMA assists in flood emergencies, especially with post-disaster recovery.

FEMA also plays an important role in providing federal disaster assistance in the Delta for levees that satisfy the HMP geometry (see Section 5-2).

Other Agencies with Delta roles:

6.3.3 National Oceanic and Atmospheric Administration (NOAA)

NOAA's National Weather Service (NWS) and River Forecast Center will continue working with DWR on technical studies, flood forecasting and warning, and other activities related to emergency response. NWS is a team member at the State-Federal Flood Operations Center during a flood emergency.

6.3.4 National Marine Fisheries Service (NMFS)

NMFS, along with other State and federal resources agencies, will provide input on opportunities for enhancing the habitat value for marine and anadromous species, will review environmental documentation for flood improvement projects under NEPA, and will be involved in permitting flood improvement projects under the federal Endangered Species Act.

6.3.5 U.S. Fish and Wildlife Service (USFWS)

The USFWS, along with other State and federal resources agencies, will provide input on opportunities for enhancing the habitat value for terrestrial and aquatic species, will review environmental documentation for flood improvement projects under NEPA, and will be involved in permitting flood improvement projects under the federal Endangered Species Act.

6.3.6 Bureau of Reclamation (USBR)

Although the USBR is primarily involved in the irrigation and hydropower purposes of its federal water projects, many USBR reservoirs also provide flood control storage. In the Central Valley watershed, these projects include Shasta Dam on the Sacramento River, Folsom Dam on the American River, New Melones Dam on the Stanislaus River, and Friant Dam on the San Joaquin River. Curtailment of pumping from the C.W. "Bill" Jones Pumping Plant (formerly CVP Tracy Pumping Plant) in the south Delta can be an important flood management tool in the event of a Delta levee failure. Central Valley

operations personnel participate in daily briefing, planning activities, and coordinated reservoir operations.

6.4 Other Stakeholders

While agencies shown in Figure 6-1 are limited to those partners that will directly perform work toward improving flood management in California, participation and input from other stakeholders is important for success of the FloodSAFE initiative in the Delta.

Tribal governments, non-governmental organizations, and businesses have strong interests and expertise to offer regarding how the FloodSAFE initiative is implemented in the Delta.

7 Related Programs

Several major planning efforts are currently in process in the Delta. When adopted, these planning efforts may recommend physical and operational changes to the Delta that may affect DWR's integrated flood and water management investments. DWR will coordinate with these ongoing planning processes to guide decisions on major upgrades to Delta levees, new projects, habitat enhancement, and other programs. Though only briefly mentioned here, each of these efforts is active and ongoing. Additional detail may be found at websites.

7.1 Bay Delta Conservation Plan (BDCP/DHCCP)

The BDCP is intended to establish a conservation strategy for the Delta infrastructure and operations of the State Water Project and Central Valley Project, as well as the power plant operations of Mirant Corporation. It is specifically intended to assure that these and any other covered activities comply with the requirements of the federal and State Endangered Species Act, Natural Community Conservation Planning Act, and other applicable laws, over a plan term up to 50 years.

Plan development can be followed on the BDCP web site:
<http://baydeltaconservationplan.com/Home.aspx>

7.2 Delta Stewardship Council's Delta Plan

The Delta Reform Act created the Delta Stewardship Council as an independent agency of the State and charged the DSC "to develop, adopt, and commence implementation of the Delta Plan...", a comprehensive, long-term management plan for the Delta, no later than January 1, 2012.

Depending on final detail of the Delta Plan and subsequent support for its implementation, the plan could alter flood management needs in the Delta.

Plan development can be followed on the Delta Stewardship Council's web site:
<http://www.deltacouncil.ca.gov/>

7.3 Land Use and Resource Management Plan

The DPC developed its Land Use and Resource Management Plan for the Primary Zone of the Delta (DPC, 2010) in 2010. This plan contains policies to guide local government uses for the Delta including policies for levees.

The plan is available on the DPC web site at
http://www.delta.ca.gov/plan_management.htm

7.4 Ongoing USACE Studies

The USACE is working on several ongoing studies related to Delta levees and flood management.

7.4.1 *Delta Islands and Levees Feasibility Study*

This feasibility study is to develop a cost-shared solution to a variety of water resources needs, ecosystem restoration, flood risk management, and issues associated with water quality and water supply.

http://www.spk.usace.army.mil/projects/civil/Delta/Delta_Islands.html

7.4.2 *CALFED Levee Stability Program*

The goal of the Levee Stability Program is to provide short-term “quick fixes” on fragile Delta levees as authorized in PL 108-361. The USACE is working directly with Delta stakeholders to develop projects to improve the stability of individual Delta levees.

The USACE short-term strategy is to move quickly to construction on high-priority levee reconstruction projects.

Among the first projects underway through the Levee Stability Program are Horseshoe Bend on Bethel Island, McCormack-Williamson Tract, River Junction, Walnut Grove, Bacon Island, and Brannan-Andrus Tract. DWR may provide funding to selected RDs to facilitate their participation with USACE in these projects.

<http://www.spk.usace.army.mil/projects/civil/Delta/CALFED.html>

7.4.3 *Federal Delta Emergency Response Planning*

- Public Law 108-361, and Senate Report 110-121 provide guidance and direction to USACE to coordinate on Delta levees emergency preparedness and response planning with appropriate State and federal agencies. The focus is to address the preparation and response to emergencies in the Delta.

7.4.4 *Central Valley Integrated Flood Management Study*

USACE is working with DWR on this multi-objective study that seeks to balance flood risk management, ecosystem restoration, and other water resource purposes and provide a long-range management program to improve flood carrying capacity while restoring and protecting environmental features. The study area includes the entire Sacramento River Basin, San Joaquin River and the Delta Basin in Central California. It encompasses about 43,000 square miles, 1,613 miles of federal levees, 1,200 miles of floodways, 56 flood control features, and one-third of the State water supply. Numerous projects are within the study area, including the Sacramento River Bank Protection Project, Folsom Dam, West Sacramento, and the Lower San Joaquin River and Tributaries Project.

7.4.5 Lower San Joaquin Feasibility Study

The purpose of this feasibility study is to determine if there is a federal interest in providing flood risk management and ecosystem restoration improvements along the lower (northern) San Joaquin River. The lower San Joaquin River study area includes the San Joaquin River from the Mariposa Bypass downstream to, and including, the city of Stockton. The study area also includes floodplains of the lower San Joaquin River and its tributaries, and the channels of the San Joaquin River in the southernmost reaches of the Delta: Paradise Cut and Old River as far north as Tracy Boulevard and Middle River as far north as Victoria Canal.

7.4.6 Sacramento River Deep Water Ship Channel Project

The Sacramento River Deep Water Ship Channel Project is a Limited Reevaluation Study to recommend navigation improvements to the ship channel. Technical studies that are in progress include hydrodynamic and salinity modeling, beneficial reuse survey, and ship simulation studies.

7.4.7 San Francisco Bay to Stockton Navigation Improvement Project

The San Francisco Bay to Stockton Deep Water Ship Channel Project is a congressionally authorized project to determine the feasibility of modifying the current dimensions of the West Richmond, Pinole Shoal, Suisun Bay, and Stockton Ship channels, and provide access to oil terminals, industry in Pittsburg, and the Port of Stockton. Current technical studies include hydrodynamic, salinity, and dissolved oxygen modeling, and beneficial reuse survey to identify additional dredged material placement sites in the project area.

7.4.8 Delta Dredged Sediment Long-Term Management Strategy

The Delta Long-Term Management Strategy (Delta LTMS) is a cooperative planning effort to examine Delta dredging, reuse, and disposal needs. The Delta LTMS will explore ways to coordinate and manage dredging, planning, regulatory approval, and implementation to protect and enhance Delta functions, ecosystem, and water quality. The goals of the LTMS are to manage dredging activities to:

- Support and maintain Delta channel functions for navigation, flood control, water conveyance, and recreation.
- Maintain and stabilize Delta levees that protect land-based activities, water conveyance, and terrestrial ecosystems.
- Protect and enhance water quality for Delta water supply and ecosystem function.

8 Glossary

Appropriate level	The term “appropriate level of flood protection” used in this document means the level of flood protection that is considered by DWR to be justified based on costs, monetary benefits, and intangible benefits and impacts.
Business as usual	The then current (2002) and assumed continuing future condition of the Delta levee system, including policies, funding, local economic conditions, available construction assets, emergency response priorities, reservoir operation water deliveries, and willingness of the State and federal governments to continue supporting preservation of the Delta as it was, then, configured.
Channel-margin habitat	This term is broadly defined as habitat for aquatic and terrestrial species that is located water side of the levees. In the Delta, this habitat is typically emergent wetland, scrub/shrub, and riparian woodland, and experiences tidal inundation.
Delta as place	In the Delta Vision Strategic Plan (2008), the Governor’s Delta Vision Blue Ribbon Task Force recognized that Delta levees support many State interests, and that the Delta itself was of value “as a place” due to its cultural, historical, and aesthetic values.
Frequently Loaded levees	Defined in FloodSAFE as levees that experience a water surface elevation of 1-foot or higher above the elevation of the levee toe at least once a day for more than 36 days per year on average. (ULDC, version 4, November 2, 2010)
Island	Delta islands are areas completely surrounded by levees. Since island areas are generally below sea level, these levees hold back water every day of the year.

Legal Delta	The legal Delta consists of approximately 738,239 acres at the confluence of the Sacramento and San Joaquin Rivers as defined in Section 12220 of the California Water Code.
Non-Project Levee	For the Delta, non-project levees are levees that are maintained by RDs or levee districts, but are not part of the SPFC. Non-project levees in the Delta include only those shown on page 38 of DWR's Sacramento-San Joaquin Delta Atlas, dated 1993.
Project levee	Project levees are those levees that are part of the State-federal flood protection system in the Sacramento-San Joaquin Valley of California. These are levees of federally authorized projects for which the State has provided assurances of cooperation to the United States federal government and are considered part of the State Plan of Flood Control (SPFC); see State Plan of Flood Control Descriptive Document (DWR, November 2010).
SEMS	Standardized Emergency Management System. This is the system of emergency management in CA required by Government Code Section 8607 to be used by all public agencies where there is an expectation of reimbursement of eligible expenses after a declared emergency.
Tract	Delta tracts are areas around the edges of the Delta that are subject to tidal influence, but do not require levees on all sides because of the presence of high ground on one side. However, some tracts have levees on the high ground portion to protect the areas from upstream runoff. Also, some islands are named as tracts – Webb Tract for example.
Water resources	As used by DWR in its mission statement, the term “water resources” has a broad meaning that includes all aspects of California’s waters – surface water, groundwater, droughts, floods, water quality, water uses and a wide array of strategies for water resources management.

9 References

- CALFED Bay-Delta Program. 2000. Levee System Integrity Program Plan.
<http://calwater.ca.gov/content/Documents/library/305-1.pdf> and
<http://calwater.ca.gov/content/Documents/library/305-2.pdf> (accessed February 9, 2011)
- _____. 2000. Seismic Vulnerability of the Sacramento-San Joaquin Delta Levees. April.
(prepared by the Levees and Channels Technical Team, Seismic Vulnerability Sub-Team)
- _____. 2007. Independent Science Board Memorandum on Sea Level Rise.
- California Department of Finance. 2004. Population by Race / Ethnicity, Gender and Age for California and Its Counties 2000-2050. May.
<http://www.dof.ca.gov/research/demographic/reports/projections/p-3/> (accessed February 19, 2011)
- _____. 2006. E-7 California Population Estimates, with Components of Change and Crude Rates, 1900-2006. December.
<http://www.dof.ca.gov/research/demographic/reports/view.php#objCollapsiblePanelEstimatesAnchor> (accessed February 19, 2011)
- California Department of Water Resources (DWR). 1982. Bulletin 192-82, Delta Levees Investigation. December.
<http://www.archive.org/stream/gt6deltaleveesinves19282calirich#page/n0/mode/2up> (accessed February 17, 2011)
- _____. 1983. State of California Flood Hazard Mitigation Plan for the Sacramento–San Joaquin Delta. Prepared for the Office of Emergency Services. September.
- _____. 1986. State of California – Flood Hazard Mitigation Plan – 180-Day Report Prepared in Accordance with Section 406 of Public Law 93-288; Section 2 – The Sacramento-San Joaquin Delta Flood Hazard Mitigation Plan. August.
- _____. 1986. Sacramento-San Joaquin Delta Emergency Water Plan – Report to Legislature. December.
http://www.water.ca.gov/floodmgmt/docs/FloodEmergencyPlan_1986.pdf (accessed February 19, 2011)
- _____. 1990. Geometry Criteria for Rehabilitating Existing Local levees in Sacramento-San Joaquin Delta, Draft Memorandum Report. July.

- _____. 1993. Sacramento-San Joaquin Delta Atlas.
<http://baydeltaoffice.water.ca.gov/DeltaAtlas/index.cfm> (accessed February 19, 2011)
- _____. 2005. DWR Strategic Business Plan. <http://www.water.ca.gov/about/mission.cfm> (accessed February 15, 2011)
- _____. 2007. Bond Expenditure Plan.
- _____. 2007. Delta Emergency Operations Concept Paper (Interim Plan). April.
http://www.water.ca.gov/floodmgmt/docs/Delta_EOP_Concept_Paper-March_2007.pdf (accessed February 19, 2011)
- _____. 2009. Sustainability Policy. April.
http://www.water.ca.gov/climatechange/docs/Sustainability_Policy.pdf (accessed February 17, 2011)
- _____. 2010. Environmental Stewardship Policy Paper .March.
<http://www.waterplan.water.ca.gov/docs/news/EnvironmentalStewardshipPolicy2010.pdf> (accessed February 17, 2011)
- _____. 2010. Draft FloodSAFE Implementation Plan. March.
- _____. 2010. Delta levees Special Flood Control Projects, Final Near-Term Guidelines for Providing Funding to Local Public Agencies. February.
http://www.water.ca.gov/floodmgmt/dsmo/docs/Final_Near_Term_Guidelines_v_2-16-10.pdf (accessed February 17, 2011)
- _____. 2010. Implementing California Flood Legislation into Local Land Use Planning: A Handbook for Local Communities. October.
http://www.water.ca.gov/floodmgmt/lrafmo/fmb/docs/Oct2010_DWR_Handbook_web.pdf (accessed February 21, 2011)
- _____. 2010. State Plan of Flood Control Descriptive Document. November.
<http://www.water.ca.gov/cvfmp/docs/SPFCDescriptiveDocumentNov2010.pdf> (accessed February 19, 2011)
- _____. 2010. Interim Levee Design Criteria for Urban and Urbanizing Areas in the Sacramento-San Joaquin Valley Version 4. December.
http://www.water.ca.gov/calendar/materials/ildc_version_4_12-15-10_final_10532.pdf (accessed February 20, 2011)

California Ocean Protection Council. 2011. Resolution of the California Ocean Protection Council on Sea-Level Rise Adopted on March 11, 2011.

- Central Valley Flood Protection Board. 2009. Delta levees Maintenance Subventions Program, Procedures and Criteria. September.
<http://www.water.ca.gov/floodmgmt/dsmo/bdlb/sp/guidelines.cfm> (accessed February 17, 2011)
- Das et al, 2010. Tapash Das, Michael D. Dettinger, Daniel R. Cayan, and Hugo G. Hidalgo. Potential increase in floods in California's Sierra Nevada under future climate projections. Draft manuscript. Submitted to Climatic Change. February.
- Delta Protection Commission. 2010. Land Use & Resource Management Plan for the Primary Zone of the Delta. October.
http://www.delta.ca.gov/plan_management.htm (accessed February 19, 2011)
- Delta Stewardship Council. 2010. Flood Risk White Paper. October.
http://www.deltacouncil.ca.gov/delta_council_meetings/october_2010/Item_11_Attach_2.pdf (accessed February 17, 2011)
- FEMA, et. al. 2010. Memorandum of Understanding between the State of California Emergency Management Agency and the U.S. Department of Homeland Security's Federal Emergency Management Agency, Regarding Criteria for Public Assistance Eligibility for Reclamation Districts in the Sacramento/San Joaquin legal Delta. February.
[http://www.calema.ca.gov/WebPage/oeswebsite.nsf/699b301869389a02882573c900817d70/f20c87853eda129888257527006ba118/\\$FILE/Legal%20Delta%20MOU.PDF](http://www.calema.ca.gov/WebPage/oeswebsite.nsf/699b301869389a02882573c900817d70/f20c87853eda129888257527006ba118/$FILE/Legal%20Delta%20MOU.PDF) (accessed February 17, 2011)
- Jack R. Benjamin & Associates, Inc. 2005. Preliminary Seismic Risk Analysis Associated with Levee Failures in the Sacramento-San Joaquin Delta
http://calwater.ca.gov/content/Documents/library/Delta_Seismic_Risk_Report.pdf (accessed February 9, 2011)
- Kelley, Robert. 1989. Battling the Inland Sea - Floods, Public Policy, and the Sacramento Valley. University of California Press.
- Mitchell, Martin D. 1994. Land and Water Policies in the Sacramento-San Joaquin Delta. *Geographical Review*, Vol. 84, No. 4 (Oct. 1994), pp. 411-423.
- Public Policy Institute of California (PPIC). 2008. Comparing Futures for the Sacramento-San Joaquin Delta, Technical Appendix B Levee Decisions and Sustainability for the Delta. <http://www.pplic.org/main/publication.asp?i=810> (accessed February 9, 2011).
- Thompson, John, 1957. The Settlement Geography of the Sacramento-San Joaquin Delta, California. PhD Dissertation. Stanford University.
- _____. 1996. Flood Chronologies and Aftermaths Affecting the Lower Sacramento River, 1878-1909. California Department of Water Resources. November.

_____. 2006. Early Reclamation and Abandonment of the Central Sacramento-San Joaquin Delta. Sacramento History Journal of the Sacramento County Historical Society. Vol. VI, No. 1-4, pp. 41- 72

URS Corporation & Jack Benjamin Associates. 2008. Delta Risk Management Strategy. http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/phase1_information.cfm (accessed February 9, 2011)

US Army Corps of Engineers. 1987. Guidelines for Rehabilitation of Non-Federal Levees in the Sacramento-San Joaquin Legal Delta, CA. September.

_____. 1992. Sacramento-San Joaquin Delta, California, Special Study, Hydrology. February.

USACE Delta Specific PL 84-99 design criteria